BETT BUILDINGS ENERGY TECHNOLOGY
TRANSFER PROGRAM

Air Sealing Homes
For Energy Conservation

SECOND
DRAFT

Canada

Air Sealing Homes For Energy Conservation

SECOND DRAFT

A Project of the:

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The Buildings Energy Technology Transfer Program (BETT) of EMR has been created to assist building owners, users and practitioners active in the design, construction and operation of buildings in identifying technical obstacles to energy conservation. Through a nationwide network of research agencies and private sector consultants, BETT carrries out research and development projects and provides the audiences mentioned above with technical reports, how-to manuals, training manuals, audio-visual aids and data bases to help them overcome these obstacles.

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A previous draft of this document was submitted to the Canadian General Standards Board Working Group on Air Sealing. Please refer to the Letter to the Reader (opposite) for further details.

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NOTE: THIS DOCUMENT IS A REVISED AND UPDATED VERSION OF HANDBOOK ON AIR SEALING HOMES FOR ENERGY CONSERVATION: PRELIMINARY EDITION (ISBN 0-622-12735-8; Catalogue number M92-6/1983E).

LETTER TO THE READER

Air Sealing Homes for Energy Conservation is a draft document intended to assist a number of initiatives being undertaken to develop the technology of home air sealing. One of these initiatives is the preparation of a provisional Standard on Air Sealing of Homes for Energy Conservation, currently under development by the Canadian General Standards Board (CGSB) Working Group on Air Sealing. In the interim, prior to completion of the provisional standard, the Buildings Energy Technology Transfer (BETT) program of Energy, Mines and Resources Canada is distributing this document to insulation contractors, other energy conservation contractors, manufacturers, codes and standards writing organizations, and experts in the air sealing field. This distribution is intended to solicit feedback for the CGSB Working Group.

The first draft of this document was reviewed by the CGSB Working Group on Air Sealing. It was adopted by the Working Group as a working document in the preparation of the provisional standard. This present draft document has been partially updated to incorporate some of the key changes recommended by the Working Group, but it has not been reviewed by the Working Group in its updated form.

A number of technical issues remain unresolved. Among these issues are two very important **health and safety** concerns:

1. Ventilation Requirements: Is it possible to develop a formula to identify the indoor ventilation requirements in houses? Can procedures be developed to test for compliance with these requirements?

2. Combustion Air Requirements: What type of acceptable test can be developed to ensure that adequate air is supplied to combustion appliances? What specific standards are required for the installation of combustion air supply systems?

Contractors currently engaged in air sealing should recognize that these are key issues affecting the health and safety of house occupants, and that these gaps in our current knowledge require that air sealing be carried out with caution. It is the contractors' primary responsibility to ensure that homes which have been air sealed are not left with either inadequate ventilation or an inadequate supply of combustion air. (Discussion of these matters can be found in Chapters 3 and 4 of this document.) A considerable research effort is being applied to help resolve these various technical issues.

If you have any comments on this draft document, please use the feedback form included at the end of the document. Return a copy to one or both of the addresses indicated.

A final comment: this revised document will be submitted to the CGSB Working Group on Air Sealing for review as part of the development of a CGSB provisional standard on air sealing. The contents of this document will be superseded by subsequent CGSB-approved drafts and by the published edition of the CGSB provisional standard.

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Preface

PURPOSE

The purposes of this Manual are:

1. To provide standards writing committees with technical information to assist in the development of standards on air sealing and air sealing materials.

2. To encourage discussion and input by contractors, manufacturers, government agencies, those reponsible for codes and other experts on the technology and technical issues relating to the air sealing of homes.

3. To be a guide and reference text for organizations providing or planning courses of instruction in the fields of air sealing and energy conservation in homes.

4. To serve as a specification for research and development organizations wishing to carry out studies of the effects of air sealing techniques on house energy consumption, air quality, combustion air supply and the reduction of moisture damage to the house structure.

OVERVIEW

This Manual describes the air sealing of existing houses (i.e., low-rise residential) through the application of:

- Sealants
- Weatherstripping
- Air-vapour barriers
- Other products and techniques.

It is divided into three sections:

- I. The Principles of Air Sealing covers the basic concepts of air exchange, moisture movement, and air sealing. In addition, it discusses the control of indoor air quality and the assurance of adequate combustion air supply in extremely well sealed homes. This section should be read by all employees of contracting companies, including installers, in order to gain an understanding of the fundamentals of air sealing.

- II. Assessment Procedures identifies the procedures that can be used to assess individual houses to determine what air sealing measures should be undertaken. It provides an indication of priority amongst those measures and identifies a number of example sealing "packages" for a variety of circumstances. This section should be read carefully by company owners, estimators, and installers-in-charge.

- III. Air Sealing Practices covers the various materials used for air sealing work, their characteristics, and their preferred applications. Sealing procedures are presented for each element of the house and for most situations or construction techniques likely to be encountered. Step-by-step "how-to" instructions are provided in the form of Worksheets which outline tools, materials, preparation, and application procedures for each case. This section should be read by company owners, estimators, crew foremen, and, in particular, by the individual installers.

The Manual also contains a draft glossary of terms; appendices containing data sheets on various sealants and weatherstripping materials; and a feedback form for comments from readers.

Section I: The Principles of Air Sealing

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Chapter 1: Introduction to the Principles of Air Sealing

DEFINITION AND IMPORTANCE

The terms air sealing and air tightening, as employed in this Manual, refer to a new specialization in building energy retrofit and construction. Air sealing measures are not simply the familiar caulking and weatherstripping practices of years gone by, which tended to be rather hit and miss; they are much more.

Air sealing is a systematic and comprehensive approach to stopping up the cracks and holes which allow for uncontrolled infiltration and exfiltration of air and moisture in homes. Many of these leakage points are not at all obvious to the householder or the untrained contractor.

Air sealing measures are primarily installed on the inner (warm) surface of the structure. The few exceptions to this rule are noted in this Manual. Exterior caulking, applied to protect the structure against moisture penetration, is not an energy conservation measure and is not dealt with in this Manual.

The methods used in air sealing include sealant application, weatherstripping, installation of air-vapour barriers, and the use of a variety of new products such as urethane foams. Through the choice of the proper materials and the use of proper techniques, it is possible to completely seal a given air leakage point. Note, however, that it is only possible to tighten an entire house - never completely seal it - because of hidden or inaccessable sites of leakage.

Air sealing is important to today's householder because it can:

- reduce heating and cooling costs
- improve home comfort by cutting drafts and modifying humidity levels
- prevent or arrest deterioriation of the building structure by reducing moisture penetration from household air into ceilings, walls, and other areas.

These major benefits are discussed in more detail in Chapter 2, along with a discussion of the fundamentals of air exchange.

For definitions of specialized air sealing terminology, refer to the glossary at the end of this Manual.

AIR SEALING AS PART OF COMPREHENSIVE RETROFIT

Three factors have caused air sealing to become regarded as an important part of modern home energy retrofit:

- A recognition of the important role of air exchange as a mechanism of heat loss in homes. It was formerly thought that air leaks accounted for perhaps 10-15% of total heat loss but it is now recognized to be more in the range of 20-50%.
- A recognition of the moisture damage problem. When moisture and ice buildup occurred in recently insulated attics and walls in many new and existing houses, the importance of air-vapour barriers and air sealing was strongly reinforced. The undertaking of extensive reinsulation without comprehensive air sealing risks significant damage from trapped moisture. (See Chapter 2.)
- A recognition of the many varied and often obscure points of air leakage in a house. At one time, air leakage was widely assumed to occur mostly around windows and doors and to require simple weatherstripping and caulking as a remedy. However, wall bottom plates, electrical outlets, light fixtures in ceilings, partition walls, pipes, vents, baseboards, cracks in basement walls, and many other sites are important points of air exchange. Insulation and original conventional vapour barriers do little to stop this leakage. These points require a professional air sealing approach, using specialized tools, materials, and skills.

These technical factors, together with the continued escalation in energy prices, greater public awareness, and ongoing government financial assistance programs, mean that householders are now approaching home energy retrofit in a more logical, comprehensive, and long-term manner. Making a home energy efficient is not a simple, one-step process

- it is not enough to simply blow insulation into the attic. From both a technical and an economic point of view, effective home energy retrofit now consists of three essential steps, in the following order:

No. 1 Air sealing (including air management measures, if required)
No. 2 Reinsulation
No. 3 Heating system conversion or upgrading.

Air sealing is now regarded as an important, and usually necessary, first step in the process of effectively retrofitting a home to achieve maximum energy savings at reasonable costs and with minimal undesireable side effects. Specifically, as is outlined in Chapter 2, sealing should normally precede insulating, in order to avoid possible moisture problems.

This Manual attempts to help provide the understanding and skills needed to create a knowledgable and quality-conscious air sealing industry in Canada. Such an industry will successfully fill the existing demand for air sealing services, and will foster a larger market by creating a public perception of an important service provided by a reliable and professional industry.

THE NECESSITY FOR QUALITY SEALING

Quality is crucial in the air sealing business.

Poor sealing work not only yields a lower return in energy savings (either now or in the future) but can also eventually cause or allow structural damage through moisture penetration of wall cavities and attics. Worse, inattention to all aspects of the sealing contractor's responsibilities can, in some cases, produce health risks for the householder.

Quality sealing consists of at least four elements.

- Assessment - It is essential to correctly identify the priority air sealing requirements of a given house. Choosing the wrong sealing package will, as a minimum, mean that all the potential benefits of sealing are not realized. At worst, the sealing could create a number of problems for the householder.
- Products - Selection of appropriate sealants, weatherstripping or other products for each site is vital. Products should be durable, effective, functional, and aesthetically acceptable.
- Application - Contractors should deal with all of the areas to be sealed in a comprehensive manner, sealing each selected site as completely as possible. Contractors should, of course, use correct application procedures for each site.
- Remedial measures - Identifying and remedying any potential problems resulting from sealing is a major responsbility for every air sealing contractor. Probably the most important potential problems are related to air quality and combustion air supply, as is highlighted in the next section of this chapter.

AIR SEALING AND AIR MANAGEMENT: A CAUTIONARY NOTE

Air sealing homes reduces uncontrolled infiltration and exfiltration. **At very low levels of air exchange, two major potential problems could occur. The concentration of indoor air contaminants (moisture, carbon dioxide, carbon monoxide, smoke, odours, etc.) could rise to undesirable levels. Also the combustion air required by furnaces or other combustion appliances may not be readily available and this may result in poor combustion and even the escape of dangerous combustion products into the house.**

In most cases, air tightening will probably not lead to air quality problems or excessive moisture build-up in the living space. However, in houses where this Manual's air sealing measures achieve a high standard of air tightness (most likely in the case of homes built after 1976 which were more tightly built to start with), it is important to provide adequate controlled ventilation and an adequate combustion air supply. Note that controlled ventilation does not, as is sometimes assumed, negate the benefits of air sealing. Controlled ventilation is superior to uncontrolled air leakage in terms of cleaner air, controlled humidity levels, lower heating costs, better temperature control, fewer drafts, and a natural cooling effect in the summer.

Chapters 3 and 4 provide a discussion of the potential air management problems in a well sealed house, together with a review of the available remedies. These Chapters should be carefully studied by contractors.

Chapter 2: Fundamentals of Air Exchange

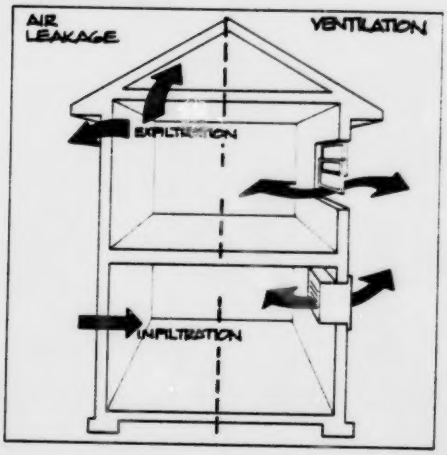
DEFINITIONS

In every house there is a continuous exchange of air between the house and its surroundings. This air exchange has two components: **ventilation** and **air leakage**.

- **Ventilation** means controlled air exchange. It applies to systems such as bathroom vents, kitchen range vents, dryer vents, and even open windows - anything which can be controlled by the house occupants.
- **Air leakage** means uncontrolled air exchange. It occurs through the many small openings in the building envelope: drywall cracks, structural joints, concrete cracks, gaps around windows, and so on.

Air leakage can occur in both directions. When the leakage is from inside to outside it is called **exfiltration**. When the leakage is in the opposite direction, it is called **infiltration**.

FIGURE 2.1



The term **air exchange** covers all three processes: ventilation, infiltration, and exfiltration (see Figure 2.1).

Air change rates are normally expressed in the form of **air changes per hour**. This may be abbreviated to "acph" or "ach". If a house has an air change rate of 1.0 acph, this means that the total volume of air in the house is changed every hour. For 0.5 acph, only one half of the house air is changed every hour.

The air change rate can be expressed more precisely, in the form of cubic metres per hour (m^3/h) or litres per second (L/s). This is easily calculated. For instance, if a house has an air change rate of 0.5 acph and the volume of the house is 600 m^3, then:

PRESSURE PATTERNS AROUND A HOUSE

$$\text{Air change rate} = 600 \times 0.5 = 300\ \text{m}^3/\text{h} = 300{,}000\ \text{L/h} = 5{,}000\ \text{L/s}$$

Note: 1 cubic metre = 1,000 litres

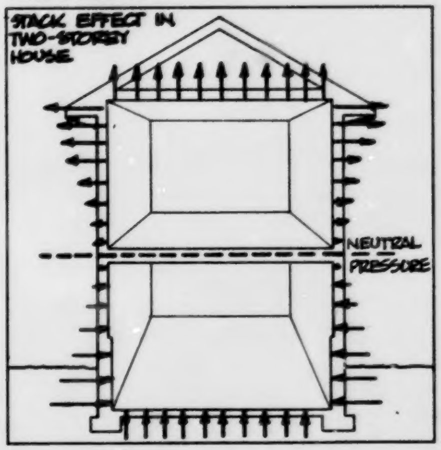
Air exchange will not occur unless there are pressure effects which cause the air to flow. In normal operation, a house experiences four different kinds of pressure effect:

- Stack effect
- Flue effect
- Ventilation effect
- Wind effect.

Each of these four effects is considered below:

Stack Effect

FIGURE 2.2

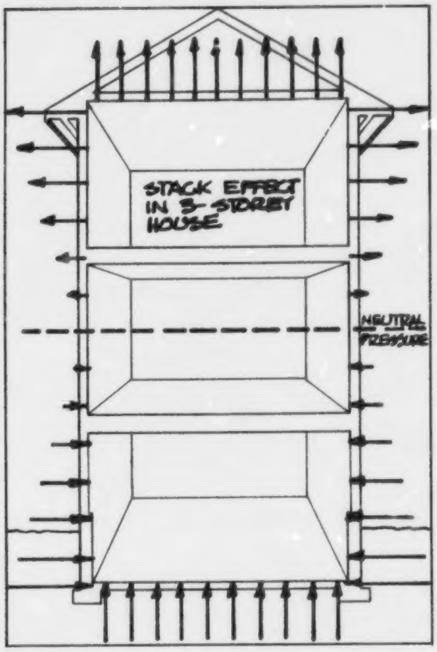


STACK EFFECT IN TWO-STOREY HOUSE

In winter, the air inside the house is warmer than that outside; it therefore has a lower density. This density difference, between the inside and outside air, sets up a pressure difference across the building envelope. The pattern of this pressure difference is shown in Figure 2.2, where the arrows show the direction and relative size of the pressure effect. This pattern is present in all heated buildings, and is known as the **stack effect**.

The stack effect increases with building height, and is a major factor in the design of very tall buildings. This Manual is concerned only with low-rise residential buildings, of three storeys or less - but the effects are still noticeable. Figure 2.3 shows the stack effect in a three-storey

FIGURE 2.3



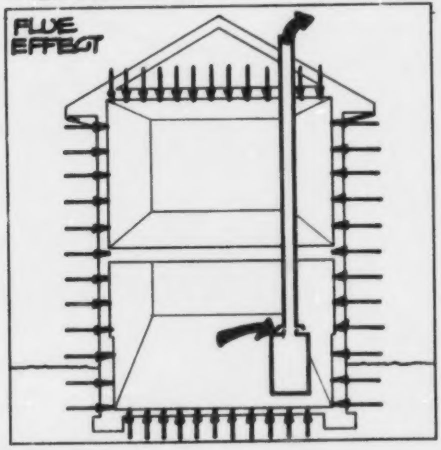
house. Note that the pressure variation, from floor to ceiling, is larger than in the two-storey house in Figure 2.2.

In some circumstances, this stack effect may be stronger than all the other pressure effects. When this happens, air will tend to infiltrate in the lower half of the house and exfiltrate in the upper half. As is discussed later, this has important consequences for moisture damage in house structures, especially in ceilings and upper walls.

Flue Effect

If a house has a flue or chimney serving a combustion appliance such as a stove, furnace, fireplace, domestic hot water heater, etc., then the flue effect is important.

FIGURE 2.4

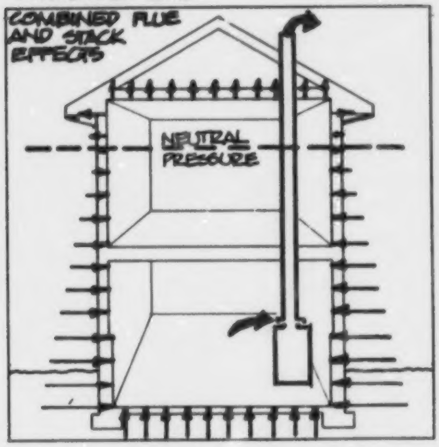


Combustion gases are very hot and have a very low density. As a result, they tend to rise rapidly up the flue or chimney, creating a strong upward draft. This sucks air out of the rest of the house and reduces its pressure. The effect is therefore as shown in Figure 2.4, with an inward pressure on all parts of the house envelope.

If this flue effect is now combined with the stack effect shown in Figure 2.2, the resulting pressure pattern is as shown in Figure 2.5.

It is instructive to compare Figures 2.2 and 2.5. In Figure 2.5 the inward pressure effect extends over a much greater section of the house envelope. Outward pressures are restricted to a fairly small region close to the upper ceiling. At some point, where the pressure changes from an inward to an outward direction, there is no pressure difference across the house envelope. One can picture this as a flat surface cutting right across the house and dividing it into two parts: one with inward

FIGURE 2.5



pressures and one with outward pressures. This dividing surface is called the **neutral pressure plane.**

Comparing Figures 2.2 and 2.5, it is seen that the flue effect raises the neutral pressure plane. This only occurs when there is a significant draft up the flue or chimney. When the combustion process stops, the flue or chimney will gradually cool down and the draft will decrease steadily. Eventually, the house will return to the pressure pattern shown in Figure 2.2. In other words, in normal house operation, the neutral pressure plane will rise and fall with each cycle of the furnace.

Ventilation effect

Most houses contain a range of exhaust vent systems, including:

- Kitchen vents
- Bathroom vents
- Dryer vents
- Vents for built-in house vacuum systems.

In older houses, of the types that are normally encountered in sealing work, the selection, design and location of these systems will vary considerably from one house to another. Some may have fans and dampers while others (such as some ceiling vent ducts in bathrooms) may have none. Regardless, it is important to note that all these systems are designed to **exhaust** air from the house. Note that openable windows are also a ventilation system but differ from the above in that they allow two way ventilation and are usually used only in warm weather.

When these exhuast vent systems are operating, they exhaust air from the house and reduce the pressure

FIGURE 2.6

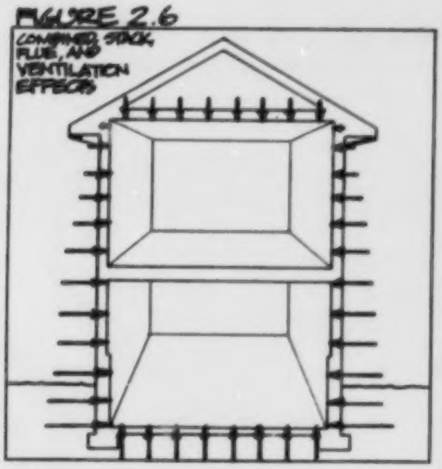


FIGURE 2.7

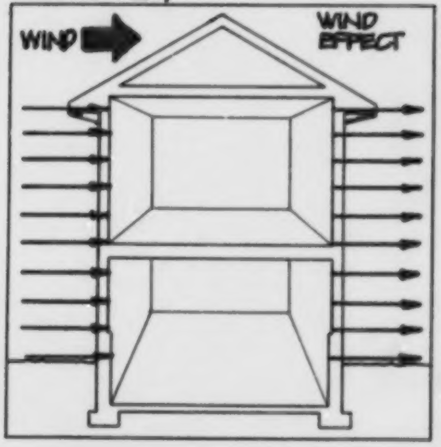
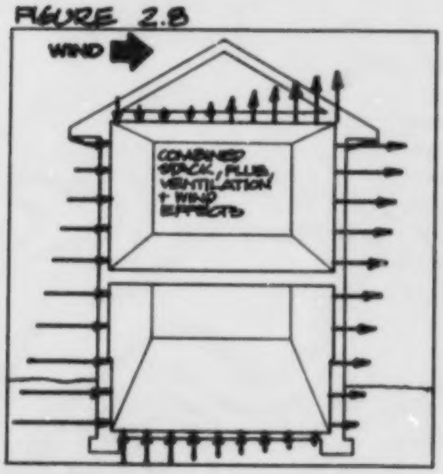


FIGURE 2.8



inside the house. Therefore, the effect is similar to the flue effect shown in Figure 2.4, with an inward pressure on all parts of the house envelope.

As the discussion of flue effect showed, the neutral pressure plane rises when the house pressure is reduced. When operating, the exhaust vent systems therefore cause the neutral pressure plane to rise.

Consider the combined impact of the three effects discussed so far: the stack effect, flue effect, and ventilation effect. When the house is operating normally, with the furnace cycling and the various ventilation systems being used intermittently, the neutral pressure plane may at times rise so high that it passes above the upper ceiling. In other words, there will be an inward pressure effect around the complete envelope of the house, as shown in Figure 2.6. The combined effects of the flue and the ventilation systems reduce the pressure inside the house, causing a suction effect all around the house envelope. This is strong enough to overcome the outward pressures that arise from the stack effect.

Wind effect

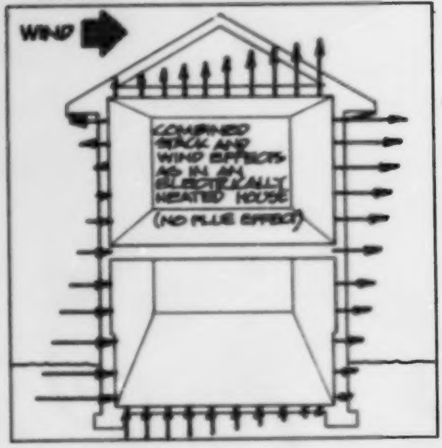
From everyday experience, it is known that wind creates pressure - the stronger the wind, the greater the pressure. When a wind blows around a house it creates an inward pressure on the up-wind side of the house, and an outward pressure on the down-wind side. A very simplified form of wind effect is shown in Figure 2.7. (In practice, there is also a complicated wind pressure pattern across the house ceiling.)

If all four effects - stack, flue, ventilation, and wind - are now combined, a pressure pattern of the sort shown in Figure 2.8 is obtained. Note that this pressure pattern is not fixed for all time; it will vary according to windspeed and direction, and will depend on whether the combustion systems and the ventilation systems are working or not. Thus, over any one-day period, the various parts of the house envelope will be exposed to changing patterns of inward and outward pressure. But:

On average, the lower part of the house envelope will experience a pressure that is mainly inwards, whereas the upper part of the envelope will experience a pressure that is mainly outwards.

Special Considerations

FIGURE 2.9


WIND
COMBINED STACK AND WIND EFFECTS AS IN AN ELECTRICALLY HEATED HOUSE
(NO FLUE EFFECT)

So far, houses have been discussed in a general way, and it has been assumed that they have some kind of a combustion heating system and some kind of ventilation system. In practice, however, it is not uncommon to come across houses that have very poor ventilation systems, or electrically-heated houses that have no combustion systems at all. In these instances, the house will have no flue effect and very little ventilation effect. When this happens, the pressure patterns around the house will be determined almost entirely by the stack effect and the wind effect, as shown in Figure 2.9.

Looking at Figures 2.8 and 2.9, it is seen that there is a more dominant outward pressure effect in Figure 2.9. This is the cause of moisture damage in houses that are poorly sealed and electrically heated. But before this can be fully understood, one must consider in more detail how the pressure patterns affect the air leakage in a house. This is done in the following section.

PRESSURE PATTERNS AND AIR LEAKAGE

The previous section showed how a fairly complicated pressure pattern exists around a house in normal operation. This section describes how these pressure effects give rise to air leakage through the house envelope.

The house envelope contains numerous openings of various sizes, shapes and locations. When pressure effects are present, these cause air leakage through the openings. The direction of air leakage is always from a region of high pressure to a region of low pressure. Thus, if there is an inward pressure acting on a certain part of the house envelope, then the air leakage will be inwards at this point. In other words, and using the definitions given earlier, an inward pressure causes **infiltration** and an outward pressure causes **exfiltration.**

In the previous section it was emphasized that the upper part of the house generally experiences an outward pressure, whereas the lower part generally experiences an inward pressure. It therefore follows that exfiltration tends to be stronger in the upper part of the house, whereas infiltration tends to be stronger in the lower part.

Air Leakage Points

The types and the sizes of air leakage openings in a house depend on two main factors: the structural details of the house and its age. Generally, older houses tend to be leakier than new ones, and some structural types, such as balloon frame construction, tend to be leakier than others. The following are the typical locations of air leakage. Detailed descriptions and methods of sealing each are provided in Section III. They are briefly reviewed here:

- Structural breaks:

  Breaks are found wherever there is some structural joint in the house envelope. Typical examples are found at floor headers, at the tops of partition walls, and at the joint of the wood frame and the concrete basement wall. If the house is new enough to have a vapour barrier, this will also have gaps in it at these points; therefore, an air leakage opening will occur through both through the frame and the vapour barrier. Often, such sites are obscured by baseboards, quarter round, hung ceilings, wall coverings, etc. These don't solve the problem - they just make it harder to get at.

- Electrical outlets:

  Outlets are significant sources of air leakage when they are located in the exterior walls or the upper ceiling, because they usually penetrate both the interior finish and the vapour barrier.

- Utilities:

  House envelopes usually contain a number of air leakage points around plumbing facilities and services, where these pass through the house envelope. Typical examples are vent stacks, drain connections, electrical service inlets, gas service inlets, fuel oil pipes, etc.

- Chimneys:

  The chimney itself is a special case, since it can be regarded as a controlled exhaust system. But chimneys are often installed poorly, leaving large air leakage gaps around the outside of the chimney where it passes through the house ceiling into the attic.

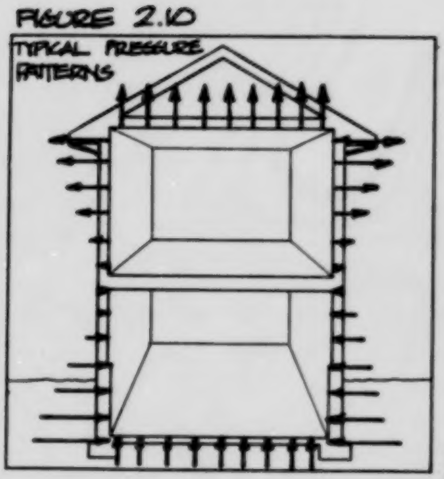
- Windows and doors:

  The air leakage openings at windows and doors can be divided into two categories. The first occurs between the window or door frame and the surrounding wall. The second category is found in the construction of the doors and windows themselves, and arises from defective or non-existent seals around the opening sections or around the glass itself.

- Basements:

  The soil around a basement does not provide a good seal against air leakage. Therefore, if a basement has cracks in the floor slab or the foundation wall, these act as air leakage openings. Basements may also allow air leakage through floor drains which are coupled to the weeping tile system around the foundation footings. In addition, in basements the structural breaks and utility penetrations, already mentioned, are important leakage points.

FIGURE 2.10

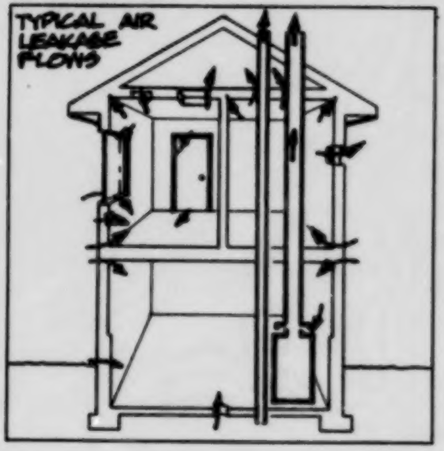


- Vents:

  Kitchen, bathroom, dryer and other vents are part of the house exhaust system and should be regarded as separate from the normal range of air leakage openings. When they are operating they serve as ventilation components, but when they are not operating they may display uncontrolled air leakage if they are not provided with good damper systems or if they are not sealed where they pass through the building envelope.

Patterns of Air Leakage

FIGURE 2.11



Under the action of the various pressure effects, some of these air leakage openings will experience infiltration and others will experience exfiltration. Figure 2.10 shows a typical pressure pattern around the house envelope, and Figure 2.11 shows the matching pattern of air leakage flows.

CONSEQUENCES OF AIR LEAKAGE

The air leakage in a house has a considerable impact on various aspects of the house performance, including:

- Moisture damage
- Comfort levels
- Heat losses
- Air quality
- Adequacy of combustion air supply.

The first two items are discussed in this section, and heat loss is discussed in the next section. Air quality and combustion air supply are dealt with in Chapters 3 and 4 respectively.

Moisture Damage

Air leakage can cause moisture damage to the house structure.

The air inside a house can have a relatively high moisture content. This is due to the various moisture-generating activities in the house: bathing, laundering, cooking, breathing, perspiration, evaporation from house plants, etc. In a typical household, as much as 11 kg of water vapour may be generated in a 24 hour period. At any one time, there may be about 2.0 to 2.5 kg of water vapour in the house air.

If humidity levels in a house are too high, an air quality problem may exist, as is discussed in Chapter 3. However, even in the absence of excessive humidity, household moisture can cause problems.

In winter, the outside air in most parts of Canada is very cold and contains an almost negligible moisture level. Effectively, this outside air can be regarded as "dry" air. In winter, the house envelope therefore has cold, dry air on the outside, and warm, relatively moist air on the inside.

When **infiltration** occurs through the house envelope, the cold dry air flows through the envelope into the house, and tends to dry-out the house structure as it passes through.

When **exfiltration** occurs, the warm moist house air passes outwards through the envelope. As it moves outwards, it gets progressively colder. At some point, either in the exterior walls or the roof structure, the moist air will have cooled to its **dewpoint temperature**. This is the temperature at which the moisture will condense from the air. When this happens, there will be a progressive build-up of moisture in the wall cavity or the roof structure. If the exterior temperature is low enough, this build-up will take the form of frost accumulation within the walls or roof space. This process will continue through the winter season, causing a progressive build-up of frost. This moisture accumulation severely reduces the insulating properties of the insulation and leads to higher fuel bills. In spring, or whenever the exterior temperature rises above the melting point, this frost will melt and form pools of water in various parts of the house structure. In the walls, it may form pools on the bottom plates, leading to rot, odour, discolouration of the walls, nail rusting, damage to electrical installations, etc. In the roof, it may form pools on the ceiling, leading to discolouration of the ceiling surface, nail rusting, damage to insulation, partial collapse of the ceiling, etc.

The severity of the effects will depend on the amount of the accumulated moisture, and this will depend largely on the rate at which moisture exfiltrates through the house envelope.

It will be recalled that exfiltration tends to be greatest in the upper parts of the house envelope: namely the ceiling and the upper sections of the exterior walls. The exfiltration in these areas accounts for many of the incidences of moisture damage in houses.

A special case of moisture damage arises when insulation is added to an attic as a retrofit measure. When the level of insulation in the attic is increased, the attic will operate at a lower temperature, since it receives less heat from the house. As a result, there is a greater risk that exfiltrating moist air will be cooled to the dewpoint temperature. Thus, even though the house may have had no moisture problems before re-insulation, there is a chance that the new level of insulation will promote such problems. **It is therefore advisable to seal the upper parts of the house envelope - the ceiling and upper walls - before re-insulating above the ceiling, even if there is no evidence of an existing moisture problem.**

A similar problem can also arise from re-insulating the walls of older houses that have no vapour barrier or are poorly sealed. If exfiltration is taking place, moisture can be deposited in the insulation. In short, to insulate the ceiling and walls of a house without first sealing may defeat the purpose of the insulation and expose the house structure to moisture damage.

A related moisture problem is excessive condensation on windows. This can be caused by excessively high humidity levels in the house, inadequate thermal resistance of the windows (eg. single panes or low quality double panes), or by high levels of air leakage. The result is pooling of water and damage to window frames (especially the sill), water damage to walls and paint, and often mold or mildew growth. If the problem is due to excessive humidity levels, refer to Chapter 3. If the problem is caused by poor thermal resistance of the window, the likely solution is upgrading the window. If the problem is due to exfiltration (usually indicated by accumulation of condensation or frost between panes), air sealing of the interior window should solve the problem.

Comfort Levels

Air leakage can reduce comfort levels in the house.

A person's thermal comfort is determined by a large number of factors, two of which are the temperature of the air around the body and the airspeed around the body. When there is a rapid movement of cold or cool air, we complain about a cold draft.

Such cold drafts are not uncommon in most Canadian houses in winter, and are usually the result of air leakage through the house envelope. In older houses, which generally have high levels of air leakage, the cold drafts are particularly noticeable. One of the additional benefits of air sealing is that it reduces drafts and increases the thermal comfort of the occupants. This, in turn, can often allow the thermostat to be set somewhat lower, while still achieving equal or improved comfort levels.

Similarly, humidity levels in some older leaky homes are unacceptably low in winter - leading to high rates of evaporation (cooling) from the body, respiratory discomfort, and annoying static electricity. Furniture and other household materials are also affected by very low humidity. Air sealing can improve humidity levels in such homes and reduce the need for humidifiers - which may simply be loading the house structure with moisture and consuming additional energy. (High levels of air sealing can, however, lead to excessive humidity, which must be corrected. This problem is covered in Chapter 3.)

AIR EXCHANGE HEAT LOSSES

Air leakage results in considerable heat loss.

Heat losses from a house occur through every component of its exterior envelope both above and below ground. Heat is lost through walls, floors, ceilings, windows, doors, etc. by a complex combination of:

- Transmission losses (conduction, convection and radiation), and
- Air exchange.

Table 2.1 shows the relative percentages of energy lost by transmission through each component of several typical houses. It also shows the relative percentage of heat lost due to air exchange passing through all components of the building envelope (including ventilation losses). Note that the transmission losses are determined mainly by the insulation levels in the house. If the insulation level is increased, the transmission heat loss is reduced and the air exchange heat loss therefore accounts for a larger proportion of the reduced total.

TABLE 2.1
PERCENTAGE OF TOTAL ANNUAL SPACE HEATING ENERGY LOSSES
(typical values only)

Source: Saskatchewan Research Council

	TRANSMISSION					AIR EXCHANGE LOSSES
	Walls (%)	Ceiling (%)	Windows (%)	Doors (%)	Basement (%)	Infiltration Exfiltration Ventilation (%)
Uninsulated Bungalow						
Vancouver	23	7	6	1	19	46
Saskatoon	33	9	8	1	25	24
Toronto	30	9	8	1	24	30
Halifax	27	8	7	1	23	36
Insulated Bungalow						
Vancouver	19	7	9	1	12	53
Saskatoon	29	11	14	1	16	29
Toronto	26	10	13	1	16	35
Halifax	24	8	10	1	15	42

As an illustration of the magnitude of air exchange, consider a house that has a volume of 500 m^3 and an air change rate of 0.5 acph at normal pressure differences. Then:

Rate of air exchange = 250 m^3/h

In a 24-hour period, about 6,000 (24 x 250) cubic metres of air will pass through the house. This amount of air weighs about 7,700 kilograms (8.5 short tons). Therefore, in a typical day, this house takes in 7,700 kg of cold air, warms it up to the normal house temperature (about 20°C) and then throws it outside again. This gives some idea of the scale of the heat losses by air exchange.

The foregoing example uses a house with an air exchange rate of 0.5 acph. In practice, there is a considerable variation of air exchange rate from one house to another, according to the structural details of the house, the age of the house and the climatic region in which it is located (which influences the stack effect).

In some of the new energy-efficient houses, the air exchange rate may be as low as 0.05 acph. In old houses, it is not unusual to find air exchange rates as high as 2.0 acph. Generally, though, the majority of the Canadian housing stock has an air exchange rate somewhere in the range 0.5 to 1.0 acph. Older houses tend to have higher air exchange rates, and there is a significant variation in air exchange rates from one region to another - due mainly to regional variations in construction practice.

The Value of Air Sealing Houses

Annual space heating bills vary considerably from house to house across Canada, depending on the climate, the type and cost of the space heating energy, and the level of thermal efficiency of the house. It is therefore difficult to give a representative annual fuel bill for a house in Canada, but for the purposes of the following discussion an annual space heating bill of $1,000 (oil heat in Toronto) will be assumed.

Using the figures in Table 2.1, it follows that air exchange heat losses may cost somewhere in the range $300 - $350 per year. This, of course, does not allow for extreme variations in house design, such as super energy-efficient houses or very leaky older houses. This estimate merely gives a rough idea of the cost range for one segment of the housing stock.

Sealing techniques can reduce air exchange heat losses by a considerable fraction. With moderate sealing work, the costs may be reduced by about 30% of the original value. Therefore, in the case of the above example, savings from air sealing could be in the range of $90 to $105 dollars (30% of $300 to $350).

The cost of this air sealing work could range from $850 to $1,200 on average. Taking account of the CHIP grant, this investment would pay for itself in roughly 3 to 8 years (or in 8 to 13 years without CHIP).

Very little monitoring work has been done on the cost savings from actual air sealing work, and therefore it is difficult to give precise figures. The above calculation is highly simplified, but it does give an idea of the factors to consider in payback calculations.

One further, important factor must be taken into account when assessing the energy savings of sealing techniques:

As has been noted, if a house is made progressively more airtight by sealing, there will come a point where the house will not have enough air exchange to satisfy the air management needs. When this

happens, it will become necessary to install some kind of ventilation system. This will involve extra cost, will cause the loss of a certain amount of heat, and will offset some of the savings of the sealing work.

Therefore, when deciding what level of sealing to attempt on a house, it is not enough to consider only the beneficial aspects of the sealing; there must also be consideration of the effects this might have on the air management balance of the house. This aspect is discussed in detail in the following two chapters.

Chapter 3:
Air Quality and the Effects of Sealing

Definition

Air quality refers to the quality of the house air as a living environment for the occupants. If the house air contains anything in quantities large enough to constitute a health hazard or source of discomfort to the occupants, or a threat to the structure of the house, then the house is said to have poor air quality.

Background

To maintain a healthy environment in a house, it is necessary to have good air quality. This means that the air has to be controlled so that water vapour, odours, chemical pollutants, biological pollutants and particulates such as dust or pollen are not allowed to build up to unhealthy or uncomfortable concentrations.

The concentration of a pollutant in house air is determined mainly by two things:

- the rate at which the pollutant is generated or introduced inside the house
- the rate at which the pollutant is flushed out of the house by air exchange.

If the pollutant is generated at a low rate and the house has a high rate of air exchange, then the concentration of the pollutant in the house air will be very low.

In most of the Canadian houses built to date, the structures are leaky and the resultant "accidental" ventilation rates are relatively high. The various pollutants are flushed out of the house as fast as they have been generated (along with valuable heat). Thus, high concentrations of pollutants have been avoided and air quality problems have been encountered only in a few extreme cases.

To understand the implications of this situation for the air sealing contractor, it is first necessary to understand the fundamentals of indoor air quality.

Factors affecting air quality

House air normally contains a great number of pollutants. As concentrations of these pollutants increase, the occupants' health or comfort will start to be affected. The safe concentration limit varies considerably from one type of pollutant to another. Also, for some pollutants, different persons have different levels of tolerance. Allergenic pollutants are a case in point; some people can tolerate quite high levels of formaldehyde or pollen, while others display allergic reactions to relatively low levels. The Department of Health and Welfare is currently preparing a list of the most important house air pollutants and their tolerable concentrations, but the foregoing discussion shows how difficult this task might be.

As stated earlier, the concentration of a pollutant in house air depends essentially on the rate of generation of the pollutant and the rate of air exchange in the house. In some cases, it may also depend on where the pollutant is generated in the house and how effective the air distribution system is in this area. A room with a poorly arranged air distribution system may display very high concentrations of pollutants that are generated in that room, even though the air exchange rate of the house may be very high.

The generation rate of pollutants is practically impossible to determine in a real house situation because it usually varies from one hour to the next or one season to the next. An example is provided by formaldehyde emission from particle board. The rate of emission will decay very slowly over a period of years due to the progressive decrease of the amount of formaldehyde in the board. However, there is a short-term variation imposed on top of this long-term decay: the rate of formaldehyde emission varies according to temperature and humidity level, and will therefore fluctuate with these changes in the house conditions. The fluctuation may have a period of days, weeks or months. Another example is provided by cooking, which is conducted intermittently throughout the day. At mealtimes, the generation of odours and humidity will be high, but at other times it will be zero.

The removal rate of the pollutant is subject to similar uncertainities. We can measure the approximate air change rate of the house, under controlled circumstances, but this will vary with season (furnance flue effects in winter, open windows in summer) and short-term conditions such as windspeed. Also, we do not know how effectively this air change is distributed around the house.

At the present time, therefore, it can be said that there is a distinct risk of air quality problems in tightly sealed houses, but the state of the art has not yet advanced to the point where these problems can be predicted ahead of time. There are uncertainties about the safe, tolerable concentrations, the rates of removal and the rates of generation of pollutants.

No firm guidance on identifying potential problems in advance can be given to sealing contractors at this time. Contractors would be well advised, however, to familiarise themselves and their customers with the air quality problems that might be created by the application of sealing techniques.

Sources and types of air pollutants

The table on the following page gives a summary of the main pollutants that are generated inside the house. It should also be borne in mind that some important pollutants can enter the house from outside. Examples are as follows:

- Radon gas, which can be generated in the surrounding soil and enter the house through the various openings in the basement
- Car exhaust fumes, which may reach high outdoor and indoor concentrations if a house is close to a busy traffic area
- Industrial emissions, when the house is downwind of an intensive industrial area
- High pollen counts
- Dust, in most areas.

In these cases air sealing is generally an advantage since it seals these pollutants out of the house.

TABLE 3.1

COMMON SOURCES AND POLLUTANT TYPES IN HOUSE AIR

Sources	Pollutant Types
BUILDING CONSTRUCTION MATERIALS:	
Concrete and stone	Radon
Particle board	Formaldehyde
Insulation	Formaldehyde, glass fibre
Fire retardant	Asbestos
Adhesives	Organics, formaldehyde
Caulks and sealants	Organics, various
Paint	Mercury, organics
BUILDING CONTENTS:	
Combustion appliances	Carbon dioxide, carbon monoxide, nitrogen oxides, sulphur dioxide, particulates
Furnishings	Odour, formaldehyde, organics
OCCUPANTS & PETS	
Metabolic activity	Carbon dioxide, water vapour, ammonia, organics, odours, biological pollutants
VARIOUS ACTIVITIES	
Cooking	Water vapour, odours
Bathing	Water vapour, odours
Laudering	Water vapour, odours, lint, organics
Cleaning	Hydrocarbons, ammonia, odours, water vapour, organics
Aerosol sprays	Fluorocarbons, vinyl chloride
Hobbies & crafts	Water vapour, organics
Tobacco smoke	Formaldehyde, carbon monoxide, cyanic acid, organics, odours

Two of the pollutants - formaldehyde and radon - have received a relatively large amount of publicity in recent years, and are perhaps the two most important pollutants that we have to contend with at the moment. Water vapour, though not strictly a pollutant, plays an important part in air quality and also has two important side effects: condensation and moisture damage. Odours are another important pollutant, since they affect our perceptions of whether the house air is fresh or not.

These four components of air quality are the ones most likely to be encountered by sealing contractors, and are therefore treated in greater detail in the following pages.

Water vapour

Water vapour is generated by a range of household activities and sources: cooking, laundering, bathing, breathing, perspiration, evaporation from indoor plants, damp basements, etc. Table 3.2 shows the amount of moisture generated from such sources in a typical home:

TABLE 3.2

MOISTURE PRODUCED BY VARIOUS HOUSEHOLD ACTIVITIES FOR A FAMILY OF FOUR

Source: Canada Mortgage and Housing Corporation Condensation in the Home: Where, Why, and What to Do About It.

Activity	Kilograms
Cooking (3 meals per day)	0.90
Dishwashing (3 meals per day)	0.45
Bathing - Shower	0.45
Bathing - Tub	0.045
Clothes washing (per week)	1.81
Clothes drying indoors or with unvented dryer (per week)	11.80
Floor mopping (per $10m^2$)	1.36
Occupants (family of 4 per day)	5.45

Water vapour is also introduced into the house with outside air. The flow of water vapour into a house may be significantly large in summer, particularly in coastal regions where the relative humidity of the outside air is usually high. But in winter, when the outside air is cold, the water vapour content is generally negligible compared with the levels in the house.

The relative humidity of the house air is a direct indication of the moisture concentration in the air. Like pollutants, this concentration is determined partly by the generation rate inside the house and partly by the air exchange rate of the house. If the house humidity level is high, this may therefore be a sign either of excessive moisture generation or of a low air change rate. Conversely, when the relative humidity is low, this may be a sign of low moisture generation or high air exchange rates. There is a tendency to treat the humidity level as an indicator of the airtightness of the house -high humidity means good airtightness and low humidity means a leaky house envelope. In most cases this may be a correct assumption, but in some cases the moisture generation rate may be the critical factor.

Humidity is unlike other components of air quality, in that it has both a high tolerable limit and a low one. If the humidity level is too low, occupants may be troubled by static electricity, dust, and dryness of the skin and respiratory tract. If the humidity level is too high, condensation and frost build-up may occur on the coldest parts of the house envelope, such as windows, doorknobs, electrical outlets in exterior walls, etc. Mould may also form in areas where there is little air movement. In addition to structural damage, this can further reduce air quality where the occupants are sensitive to mould spores, etc. Moisture damage may also be aggravated in the walls and roof structure as discussed in Chapter 2.

Odours

Odours play a major part in the perception of air quality in a house. Major sources include:

- Body odours
- Tobacco smoke
- Food preparation
- Solvents, paints, cleaning materials.

Odours are not necessarily a cause of disease, though they can cause temporary nausea, insomnia and impairment of respiration. Adverse psychological effects have been reported due to long-term exposure to some odours.

Radon

Radon is a radioactive gas that is generated by the radioactive decay of trace elements in concrete, bricks, drywall and soils. The gas decays into radioactive particles that attach themselves to dust, and may become trapped in the lungs. Extended exposure to his low-level radiation can result in lung cancer.

Very low levels of radon are generated within the house, from the concrete, drywall or bricks. But generally the greatest radon concentrations are produced by the soil around the house -particularly if the soil is of the type that has a relatively high concentration of radioactive trace elements. Fortunately, this is quite rare. Referring to some points made in Chapter 2, it will be recalled that air infiltration tends to be strongest in the lower section of a house. This infiltration airflow passes through the soil, which offers little resistance to air movement, and enters the basement through cracks in the floor and foundation wall, or through the floor drain and weeping tile system. The infiltrating air contains radon (especially in problem soils), which it has picked up in its passage through the soil. This generally constitutes the major source of radon in the house.

Formaldehyde

Formaldehyde is a component in some adhesives, and is used widely in a number of materials that find their way into houses: plywood, particle board, panelling, carpets, furnishings, etc. Attention was focussed on this pollutant as a result of air quality problems which arose in houses that had been insulated with urea formaldehyde foam insulation (UFFI). Occupants complained of eye irritation and upper respiratory ailments. The complaints were investigated and were traced to the emission of formaldehyde from the insulated wall cavities. This was being carried into the house by the infiltrating air and was also diffusing through the house drywall.

Remedial measures are now being carried out on a high proportion of these houses, under the administration of the UFFI Centre, which is an agency set up by the Department of Consumer and Corporate Affairs. For a time, the maximum permissible concentration of formaldehyde in house air was set at 0.1 parts per million by the Department of Health and Welfare, but more recently there has been a move to establish a lower figure: 0.05 parts per million.

The UFFI problem has created a greater awareness of formaldehyde and its effects on air quality. At the same time, it has also led to an increased range and availability of instruments for measuring formaldehyde levels in house air. As a result, it has been discovered that several non-UFFI houses have formaldehyde levels which often exceed those in UFFI houses. The cause has been traced to high rates of formaldehyde emission from particle board, plywood and other materials used commonly inside a house. Some manufacturers are now modifying their production techniques to reduce the formaldehyde levels in the finished product.

EFFECTS OF SEALING ON AIR QUALITY

Within the terms of reference of this Manual, sealing techniques are seen primarily as an energy conservation measure. The reduction in air exchange rate may be as high as 90%, depending on the thoroughness of the sealing work and on the limitations imposed by the house structure. More common results are in the range of 20 to 40% reduction.

As has been outlined in this chapter, the air exchange rate is the main factor that controls the air quality in the house. If sealing techniques reduce the air exchange rate by (say) 50%, then the flushing action of the air exchange is halved, and the concentration of the various pollutants will be approximately doubled. In some instances (high pollutant generation, initial low exchange rate), **this may create an air quality problem in a house that previously had no such problem.**

In the previous section, four of the main components the affect air quality were considered: water vapour, odours, radon and formaldehyde. The effects sealing will have on the concentration of these components is discussed below.

Water Vapour

Chapter 2 considered the consequences of exfiltration of moist air, and pointed out that sealing can reduce moisture damage resulting from exfiltration. However, the above discussion makes it clear that sealing will also increase house humidity levels, if the rate of moisture generation in the house remains essentially the same after sealing.

If the house humidity level was uncomfortably low before sealing, and was maintained at comfort level by the use of a humidifier, then the sealing work will probably raise the natural humidity level to a point where the occupants will be able to dispense with the humidifier.

If the house humidity level was in the comfort range before sealing (about 25% to 35% relative humidity), then the sealing may increase the humidity to an excessive level, resulting in condensation on windows, formation of mould, etc. as noted earlier. Such effects cannot be tolerated indefinitely in the house since they will eventually lead to damage of window sills, and often will cause deterioration of the drywall under windows.

If, in a more extreme case, the house showed signs of excessive humidity before sealing - in the form of condensation on windows - then a more cautious approach is required. The condensation may be due to excessive moisture generation or to poor thermal resistance of the windows. If the former applies, sealing would be inadvisable unless the occupants are prepared to adpot a "dryer" lifestyle (see Remedial Measures later). If the latter applies, it would be advisable to upgrade the windows before considering sealing.

Sealing affects the processes of moisture damage in two ways: first, as was noted in Chapter 2 and above, it reduces the size and number of openings through which water vapour can exfiltrate into the walls and roof. Secondly, it raises the water vapour content of the house air. Therefore, if any exfiltration openings are left unsealed, the rate of moisture movement through these openings may be increased. Moisture damamge may occur, though its effects may be localized.

In Chapter 2 it was noted that exfiltration tends to be strongest in the upper parts of the house envelope. This is where special care is needed to reduce the exfiltration of moisture. To repeat: when a house shows sign of moisture damage or excessive humidity in the house air - or when there is reason to suppose that sealing will create these conditions - the sealing should be applied preferentially in the upper sections of the house envelope. In the case of excessive humidity levels, remedial measures should also be applied to reduce these levels.

Odours

Sealing will increase the odour concentration in a house, in approximate proportion to the reduction in air exchange rates. This may necessitate the greater use of exhaust fans in kitchens and bathrooms, which will cause an increase in the total air exchange rate of the house, and will partly offset some of the energy savings of the sealing work.

Radon

Sealing has two effects on the radon level in a house. First, it reduces the air exchange rate, which tends to cause an increase in the radon level. Secondly, if sealing is applied to the various cracks around the basement, it will reduce the rate at which radon enters the house, and will tend to cause a reduction in radon concentration. However, radon will continue to be generated in the house, in materials such as drywall, and it will also continue to enter the house through the floor drain system and by diffusion through the basement walls. In some cases, the basement may have been developed as a living area, and it may not be possible to get at the cracks in the foundation wall. As a result, the infiltration of radon through cracks may continue unabated.

The change in radon concentration, as a result of sealing, will depend on the balance of these various factors and will vary from house to house. In some instances the floor drain may be the most important source of radon, and sealing techniques that ignore the drain will therefore raise the radon concentration by reducing the flushing action of the air exchange. In other cases, the sealing of basement cracks may eliminate the main channels of radon movement into the house, causing a reduction in the radon concentration.

Formaldehyde

The effect of sealing on formaldehyde concentrations will depend on where the formaldehyde is generated. If it is generated inside the house, in plywood, particle board, etc., then the only effect of sealing will be to reduce the flushing action of air exchange, causing a rise in the formaldehyde concentration. On the other hand, if the formaldehyde is generated in the walls, or is generated outside the house in local industrial processes, then sealing will reduce the rate of formaldehyde movement into the house by closing the various points of infiltration. This will tend to lower the formaldehyde concentration.

In houses that have been insulated with UFFI, sealing techniques are being applied as a remedial measure to reduce formaldehyde concentrations to a tolerable level. For best effect, the sealing has to be concentrated on the parts of the structure where formaldehyde is likely to enter the house. If sealing is applied at other points in the house, where there is infiltration of fresh air only - such as in the basement - then this reduces the flushing action of the fresh air and tends to raise the formaldehyde concentration.

EFFECTS OF SEALING ON AIR DISTRIBUTION

The air distribution system in a house is usually designed to distribute heat around the house, though it also plays an important role in distributing fresh air.

In older houses, the majority of air distribution systems can be expected to have defects in one form or another:

- Some houses may be heated by a gravity combustion system or a baseboard system, and may have no air distribution system as such
- In three-storey houses, the upper storey may have less than its share of air distribution because of the longer duct runs
- The arrangement of the duct system may sometimes be defective. A return air register may be located close to a warm air outlet. In such cases there will be a direct flow of air from the warm air outlet to the return air register, and the room will experience very little air movement
- In many houses, carpets may have been fitted at some recent date, but the doors may not have been undercut to give a good air gap when the door is closed. If such rooms have a warm air outlet and no cold air return, the air movement through the room will be low. In such instances, the warm outlet also tends to pressurize the room, and may force warm, humid air out of the various openings around the window. This can lead to moisture damage in the walls around the window, and may also cause extensive condensation build-up in multi-layer windows such as double-glazed sliders.

When there are such defects in the house air distribution system, the effects are often moderated by air leakage through various parts of the house envelope. This leakage creates drafts of air, and it also induces temperature variations which promote air circulation by natural convection. In these respects, air leakage may be beneficial since it improves the air distribution around the house and ensures a more uniform air quality.

When the house is sealed, these beneficial aspects of air leakage will be reduced. If the air distribution system was in any way defective to begin with, these defects will become more apparent after the sealing work has been done. Some rooms may display very good air quality, while others may display bad air quality in the form of odours or excessive condensation on windows.

After a house has been sealed, it may be necessary to modify the air distribution system to ensure a greater uniformity of air quality in all parts of the house.

REMEDIAL MEASURES FOR HIGH HUMIDITY

Extensive air sealing may result in problems of high humidity in the house - as evidenced by condensation on windows or other cold surfaces. Such humidity problems may even be encountered before sealing, in certain circumstances. In either case, there are three levels of remedial measures that can be undertaken. In increasing order of complexity and cost, these are:

- Reducing humidity generation
- Reducing cold sufaces
- Increasing ventilation.

Reducing Humidity Generation

Condensation problems are often resolved simply by reducing the generation of humidity in the house. The sources of water vapour should be identified and remedial steps taken. Common examples include:

- Furnace-attached humidifiers should be turned off or disconnected. Portable humidifiers or radiator pans should not be used
- Earth floors and earth walls in basements and crawl spaces can act as a powerful natural humidifier and should be covered with a polyethylene sheet. Covering polyethylene on the floor with a layer of sand prevents damage or movement of the sheet
- The basement should be properly drained and damp-proofed. Eavestroughs and a grade sloping away from the house will also reduce moisture problems
- Clothes dryers should be vented outdoors if this is not already the case.

There are also a number of lifestyle measures which can reduce moisture production. These "dryer lifestyle" practices include the following:

- Firewood should not be dried indoors
- Leafy, tropical plants may be reduced in number
- Drip-drying of clothes indoors should be avoided
- Pots should be covered when cooking
- Dishwashers and clothes washers should be operated with full loads to reduce frequency of use
- Baths put only one-tenth as much moisture in the air as showers.

Finally it should be noted that dehumidifiers are not effective in controlling winter humidity levels. They are not capable of reducing relative humidity below 50% during winter.

Reducing Cold Surfaces

In some situations, where humidity levels have been reduced to reasonable levels, condensation may still be taking place on certain surfaces such as windows (especially the bottom portion of north-facing windows), doors, and poorly insulated areas. This is an indication of poor thermal resistence in these areas, resulting in an inside surface temperature below the dew point. Several measures can be taken:

- Poorly fitting storm windows can be repaired, resealed or replaced altogether
- Additional glazing can be added in the form of storm windows on the interior or exterior. There are a number of products available which attach easily on the inside; make sure these are tightly sealed

- The glazing and window frame can be insulated by installing a piece of rigid insulation across the bottom either between the panes or on the outside of the window. The strips of insulation, about 150mm high, should run along the bottom of the window, covering the frame if it is metal with no thermal break. The insulation should not be placed on the inside of the house since the glass will then become colder and frost will collect

- Insulation can be added to problem areas on walls, floors and ceilings that are not insulated or where the insulation is poorly installed. Insulation does not necessarily eliminate thermal bridging caused by structural members such as corner posts, studs, bottom plates and joists; similarly, it does not eliminate the cold areas between floors. Only major retrofits can effectively deal with these areas of concern.

Increasing Ventilation

If other remedial measures haven't adequately corrected the moisture problem, it may be necessary to purposely increase ventilation of the home. This involves removing warm, moist air from the home and replacing it with cool, relatively dryer air. Since this is also the solution to other air quality problems, the various options for increased ventilation are discussed in the following subchapter.

REMEDIAL MEASURES FOR POOR AIR QUALITY

Extensive air sealing measures in a home can result in air quality problems such as odour, stuffiness or unacceptable pollutant levels. There is no simple and conclusive test to identify air quality problems. It is even harder to predict them in advance of air sealing. However, the best indicator of a potential air quality problem is:

- An air tightness test, involving fan door depressurization, which demonstrates very low levels of air exhange. (A threshold level is currently being developed.) This test is discussed in Chapter 5.

Other useful indicators that air quality problems may exist include:

- High humidity levels (which often - but not always - accompany other air quality problems)
- Lingering household odours
- Complaints of the occupants about bad air or health problems
- Evidence of combustion air supply problems (as discussed in Chapter 4).

Of course, the ultimate evidence that a problem exists is:

- An actual test showing unacceptable concentrations of one or more specific pollutants in the household air. Unfortunately, this requires the use of expensive, sophisticated equipment and is not generally feasible for the average contractor.

There is some, limited opportunity to reduce the generation of pollutants in houses. For instance, the use of freestanding kerosene heaters is not generally recommended in well sealed houses. If improperly maintained, they can give off contaminants. They also contribute large amounts of water vapour to the air, and could deplete oxygen in certain circumstances.

Unfortunately, in the case of most of the contaminants generated inside the house, the only remedy for indoor air quality problems is increased ventilation to flush the pollutants out. Many householders, unless very bothered by the problem, are reluctant to deliberately increase ventilation rates after undertaking a sealing program to reduce air exchange. However, the degree of deliberate ventilation required to resolve the problem should be much less than the uncontrolled air exchange formerly experienced. Furthermore, the methods used should be adjustable and controllable to suit the needs of the house during different times of the year. In this way, the homeowner can be assured that adequate fresh air is introduced only when needed. Finally, air-to-air heat exchangers are available which can recover heat from the exhaust air. These approaches can minimize the energy costs associated with ventilation air.

There are a number of options for increasing ventilation rates. They are outlined below roughly in increasing order of complexity, cost and overall effectiveness. They can be applied to problems of both high humidity and poor air quality. (Note that these measures are not solutions for problems of combustion air supply. If a house has both an air supply and an air quality problem, remedial measures for both are required.)

Window Ventilation

The simplest and least costly ventilation system is an openable window. A window can be opened in areas of high moisture production such as kitchens or the bathroom during a shower. To provide ventilation for the whole house, a window can be opened a crack on the first floor and another opened on the second floor. The resulting stack effect will provide extra ventilation. A disadvantage of this method is that there is no means of controlling the rate of ventilation, resulting in unnecessary heat loss. Window ventilation is also not convenient for the occupants and it causes uncomfortable drafts. In extreme climates, this method cannot be used since openable windows tend to freeze shut and can't easily be operated.

Exhaust Fans

Exhaust fans can be used selectively in kitchens, bathrooms and other areas where moisture and pollutants are produced. Fans should be free of dust and grease to operate effectively. Ideally the exhaust should be directed down and out through a floor header in order to prevent heated air from leaking to the outside and condensation from dripping back (as is the case with a vertical stack). Exhaust fans should never vent into the attic or near soffit vents. They should be capable of providing at least one air change per hour.

Exhaust fans should be used for as short a time as possible in order to prevent unnecessary heat loss and exaggerated infiltration through the remaining leakage sites. Some kitchen vents can exhaust the entire volume of house air in only twenty minutes.

When employing this method, care must be taken not to depressurize the house to the point where there is insufficient air for combustion appliances. (See Chapter 4)

The various exhaust vents in a house can be combined into one centralized exhaust system by using a manifold so that only one outside vent is required. Backdraft dampers prevent fans from interfering with each other. The whole system could be controlled by a humidistat to operate only when required. If this type of system runs fairly steadily during the winter (more than a third of the time), then an air-to-air heat exchanger may be justified and the modifications necessary to the centralized exhaust system would be minor.

Note: if gas-fired cooking appliances are present in a well sealed house, vent hoods are essential to remove carbon monoxide and nitrogen dioxide from the house.

Outside Air Duct to Cold Air Plenum

If the house has a forced air furnace, a relatively simple and inexpensive solution to humidity and air quality problems is to install an outside air duct. A length of insulated duct is installed between the outside and the cold air return plenum of the furnance. Fresh air is drawn in by the circulating fan and introduced to the house after being filtered, warmed and evenly distributed.

There should be a damper on the duct that can be adjusted periodically. The homeowner should start with an open damper and gradually close it over several cold days. When condensation appears on windows, or when other air quality problems are experienced, the damper should be opened slightly. More ventilation may be required in colder weather, so the damper should be periodically adjusted throughout the heating season. If operated properly, the energy penalty of this system is estimated to be equivalent to one percent of the fuel bill. For greater convenience, damper kits are available that have automatic dampers which can work from a humidistat.

This outside air duct remedy generates a slight positive pressure in the house, which increases exfiltration through remaining air leakage sites and increases the possibility of moisture damage as a consequence. The approach has not been thoroughly tested and evaluated; there are conflicting ideas as to its advisability.

Dummy Chimney

An insulated dummy chimney is an alternative which can be used in any house, whether it has a forced air system or not. The stack effect causes warm air to rise up the dummy chimney, which draws cold, dry air into the house through air leaks. An operable damper should be conveniently located and adjusted in the same manner as described in the option above, or it can be controlled by a humidistat. The chimney should not exhaust into the attic and should be high enough above the roof to clear potential snow accumulation. Once again, this approach has not been thoroughly tested or evaluated.

Air-To-Air heat Exchanger

Houses that require regular ventilation because they are very tight or because of other air quality requirements, may justify an air-to-air heat exchanger. These are standard equipment on most new super-efficient, airtight houses. The devices exhaust stale air to the outside and use the airstream to preheat the fresh incoming air. Typically, over the heating season, 50 per cent of the heat can be recovered. Two fans (one incoming, one outgoing) operate from a humidistat. Some units run constantly at about 25 litres/sec., kicking into a high speed of 70-100 litres/sec. when the humidistat signals excessive moisture.

Air-to-air heat exchangers are expensive ($800 to $1,500 installed) and are normally installed only if the house is very tight or if environmental conditions (such as formaldehyde gas or moisture from an indoor pool) necessitate it. In very cold climates, problems have been experienced with frosting and freezing of the core of the exchanger.

Contractors should note that the foregoing discussion of remedial measures for air quality problems is intended for their general information only and not as a prescription for dealing with specific cases. This is a new and evolving area. When faced with air quality problems, the sealing contractor should seek advice from knowledgable experts in the field.

Chapter 4:
Combustion Air Supply and the Effects of Sealing

Background

Combustion air, as the term is used in this Manual, refers to that air which is required by combustion appliances in the home for the efficient combustion of fuel in the appliance and for carrying combustion products up the flue.

Combustion appliances include the following:

- Combustion furnances (oil, natural gas, propane, wood or coal-fired)
- Combustion domestic hot water heaters (oil, natural gas or wood-fired)
- Fireplaces
- Wood stoves
- Space heaters (oil or natural gas-fired)
- Combustion cooking ranges (natural gas or propane)
- Combustion clothes dryers and refrigerators (natural gas or propane)
- Free-standing heaters (such as the kerosene heaters which have recently penetrated the market).

Most of these appliances have flues but several, such as ranges, refrigerators and free-standing heaters, do not.

In houses with any of the above combustion appliances, air is required for burning the fuel. Those with flues or chimneys also require air to ensure that there is an adequate draft to carry combustion products out of the home (dilution air).

The air required for burning and dilution is generally drawn from within the house and replaced by air infiltration or ventilation. Thus, the issue of combustion air supply is one of the quantity of air available in the home for combustion purposes, rather than the quality of that air. For this reason, combustion air supply and air quality issues are treated separately in this Manual. The remedial measures for problems in each area also tend to be different, although there is some overlap and interaction.

It should be noted that an adequate combustion air supply is not a concern to the air sealing contractor under two principal circumstances:

- When the combustion appliances are provided with their own supply of combustion air ducted directly from outside. (Some furnaces, especially in closed furnance rooms, have such a direct combustion air supply.)
- When all of the heat generating appliances in the home are electric and therefore of a non-combusting nature.

Combustion Air Requirements

Air enters a furnance or combustion appliance through the combustion chamber. The fuel, some of the oxygen in the air and, in some cases, other components of the air combine to produce combustion products (CO_2, CO, NO_x, SO_2, and various particulates, depending on the fuel and combustion efficiency). These combustion products, along with excess air and dilution air, are then usually exhausted to the outside through the flue.

Combustion air is only required when the burner is on. The amount of air required will depend on the rate at which fuel is burned. It must be remembered that pilot lights on gas appliances also require small amounts of air.

The air requirements for various typical combustion appliances are shown in Table 4.1.

TABLE 4.1:

AIR REQUIREMENTS FOR COMBUSTION APPLIANCES (L/s = LITRES PER SECOND)

Appliance	**Air Requirements**		
	Combustion	Dilution	Total
Oil Furnace (29.3 kW input)	13 L/s	55 L/s	68 L/s
Gas Furnance (29.3 kW input)	11 L/s	31 L/s	42 L/s
Domestic Hot Water Heater			9 L/s
Fireplace (2 kg of hardwood per hour)			188 L/s
Woodstove (6 to 9 kW)			5 L/s

Consequences of Inadequate Combustion Air Supply

If, for any number of reasons, there is insufficient combustion air available to an appliance, backdrafting, pulsations or sooting can occur. If the householder or contractor identifies any of these symptoms, a registered heating contractor should be called in immediately. (Note that these symptoms can also be caused by a blockage in the chimney due to debris, ice build-up or some other cause. This situation is discussed briefly at the end of this chapter.)

The most serious consequences occur when the combustion equipment backdrafts. This introduces a range of pollutants into the house. While nitrogen oxides, sulphur dioxide and carbon dioxide cause respiratory problems, carbon monoxide is the most dangerous. It binds to haemoglobin in blood, displacing oxygen. At low levels, exposure to carbon monoxide (CO) can cause symptoms such as headaches, dizziness, weakness, nausea, vomiting, or loss of muscle control. Exposure to high concentrations of CO, for even short periods, can lead to unconsciousness, brain damage, and death.

EFFECTS OF AIR SEALING

The consequences of sealing depend on the level of airtightness that is achieved. If the sealing work is aimed at achieving a moderate level of airtightness, then the air leakage processes of the house will generally continue to provide enough air for the combustion processes. This means that if the foundation is sealed (as an example), then the combustion appliances will tend to draw their air through other parts of the house envelope.

If the sealing work is aimed at a high level of airtightness, then the rate of air leakage through the house envelope may not be great enough to sustain the combustion processes. If this happens, the combustion appliances will compete strongly with each other and with the ventilation systems in the house. This, in turn, can create various short-term hazards or longer-term air quality problems:

- A combustion furnace may cause a fireplace to backdraft. This will draw air down the fireplace chimney, and will introduce smoke and harmful combustion products into the house air
- Conversely, a fireplace may cause a furnance to backdraft, drawing the harmful flue gases into the house
- When a furnance and a cooking range are being operated at the same time, the furnace may cause the range vent to backdraft (or vise versa). In each case this could result in a build-up of harmful combustion products or odours
- When a bathroom vent, range vent, or dryer exhaust vent are operating, these may cause combustion appliances to backdraft.

There are many more undesirable interactions of this sort. It is obvious that, where a house is sealed to a high level of airtightness, it may be essential to provide the house with an improved air supply system that provides enough air to avoid backdrafting and other related problems.

It is most strongly recommended that, where a house is to be sealed to a high level of airtightness, the contractor should first educate the householder about the problems that might arise, and about the necessary improvements to the air supply system (with their associated costs).

REMEDIAL MEASURES

Where extensive air sealing measures result in such a high degree of airtightness that insufficient combustion air is available to the furnace or other combustion appliances in the home, **remedial measures must be taken**. Note that, in marginal circumstances, the combustion air supply may be sufficient until several such appliances operate simultaneously or an exhaust fan or open upper story window creates negative pressure in the home. Even such marginal situations are dangerous, and must be identified and remedied. The house should be able to withstand the worst combination of conditions without creating any risk to the occupants. It is the air sealing contractor's responsibility to see that the house conforms to this requirement.

In order to determine the existence of a problem, there are three possible indicators.

The first is a backdraft test, which identifies potential problems by simulating the conditions most likely to create backdrafting. Details of this test are not included here, since the research necessary to demonstrate its safety and effectiveness has not been completed.

A second indicator that is probably less sensitive to real-life situations is an airtightness test (see Chapter 5). Using a door fan, the test can be performed to determine the rate of air infiltration after air sealing. If the rate of infiltration is less than the combined requirements of combustion appliances and exhaust systems (as determined by rated capacities and requirements) then there is a problem. It is difficult, however, to quantify the air supply requirements of a fireplace or an open upper-storey window.

The final and least desirable indicator is actual reports by the occupants. If the occupants report combustion odours, sooting, pulsations of combustion applicances, backdrafting, or health problems, this is a strong indicator of a serious combustion air supply deficiency.

There are two sets of corrective measures available for combustion air supply problems that develop:

- Precautionary measures to avoid occasional competition for air

- Remedial measures to solve ongoing problems of insufficient air for major combustion appliances.

The precautionary measures are outlined first.

- Fireplace Air Supply

  If a fireplace is used in a house, it should have its own air supply. A 150mm insulated duct can be run from outside to just in front of the fireplace. There should be an adequate damper that is closed when the fireplace is not in use. Alternatively, a window should be open in the same room as the fireplace when it is in use.

- Open Upper Storey Windows

  Open windows on an upper floor should be avoided. Some homeowners leave them open because the upper floors are uncomfortably hot. The open window acts as an exhaust vent due to the stack effect. In these circumstances, the heat distribution system should be balanced by a heating contractor to prevent the upper floors from overheating, thus eliminating the need for the open window.

- Exhaust Fans

  Exhaust fans should always be used with discretion. Prolonged use wastes heat and could create competition with the chimney. Power attic vents should not be run during winter or when the furnace is on, particularly if the attic has not been air-sealed. The power vent can pull air from the house into the attic.

The remedial measures for insufficient combustion air involve several variations for bringing outside air to the combustion appliance. These are discussed below.

Supplying Combustion Air Through the Cold Air Plenum

If a forced air furnace is open to the rest of the house (not in an enclosed furnace room), then supplementary combustion air can be brought in from outdoors via an insulated duct connected to the cold air or return plenum. This is similar to the remedy cited in Chapter 3 for air quality or humidity problems. However, in this case a hole or vent is also cut in the supply or hot air plenum downstream from the circulating fan. This hole provides the furnace area with preheated air, in effect drawn from the outside when the furnace is operating. If there is a damper in the duct, it must be equipped with an interlocking mechanism to ensure that it is in the open position prior to burning. The duct should be sized to provide 4.4. cm^2 per kilowatt of the total rating of all combustion appliances. This technique has not been thoroughly evaluated, and there are conflicting ideas regarding its advisability. Local codes may preclude its use.

It is both dangerous and against the code to supply outside air via a duct connected directly to the burner or dilution air intake, unless the furnance is specifically designed for this arrangement.

Supplying Combustion Air to an Enclosed Furnace Room

If the furnace or other combustion appliance is in an enclosed room, outside air can be supplied through ducts running from outdoors into the furnace room space. (Note that air ducts from outdoors can also be used where the combustion device is not situated in an enclosed room.)

Both gas and oil furnaces require two ducts. For details, contractors should refer to the:

- Installation Code for Natural Gas Burning Appliances and Equipment (Canadian Gas Association CAN1-B149.1-M80), or
- Installation Code for Oil Burning Equipment (Canadian Standards Association Standard B139-1976).

If cold outside air is drawn directly into an enclosed furnace room, the room should be moderately well sealed from the rest of the house using the sealing techniques presented in this Manual. The door should be weatherstripped and the joints in the plenums and ducts should be sealed with duct tape. Cloth backed or high temperature duct tape should be used on the warm air plenum joints.

Heat loss from the furnace body and warm air plenum counters the cooling effect of the incoming outside air. As a result, ambient temperatures in the area of the furnace should be between 10° and 20°C.

The temperature in the furnace room should not be allowed to drop below about 10°C. If it does, excessive condensation or even freezing may occur in the flue(s) and the operation of the furnace itself might be impeded. Some experts have suggested that one way to guard against this is to install a small exhaust fan in the furnace room wall to bring warm air from the house into the room during furnace operation. This also provides a desirable slightly negative pressure in the house.

Caution should be exercised in employing closed furnace rooms that isolate the furnace from the house, as there has been only limited experience with this approach to date.

New Furnace

If the homeowner is buying a new heating system, furnaces with low or no indoor air requirements should be considered. High efficiency gas condensing furnaces and induced fan furnaces require a minimal amount of dilution air while high efficiency gas pulse furnaces are provided with combustion/dilution air directly from outside. These types of furnaces do not require a chimney.

A Cautionary Note

Contractors should note that the following two systems are not adequate remedies for combustion air supply problems:

- Air-to-air heat exchangers
- Outside air duct to cold air plenum (i.e. without an additional hole in the warm air plenum).

These systems are designed to deal with humidity and air quality problems only. If a house has both air quality and combustion air supply problems, remedial measures for both are necessary.

Contractors should note that the foregoing discussion of remedial measures for combustion air supply problems is intended for their general information only and not as a prescription for dealing with specific cases. This is a new and evolving area. When faced with such problems, the air sealing contractor should seek advice from knowledgeable experts in the field.

A RELATED PROBLEM: CHIMNEY CONDENSATION

Condensation of water vapour in the chimney of a furnace is a problem that can exist in a house before air sealing. It causes poor draft and symptoms similar to insufficient combustion air supply. It is also a problem that can be triggered, in some cases, by air sealing and by conversion from oil to gas furnaces. The problem occurs when the exhaust gases cool to the point where moisture condenses on the sides of a chimney flue. This can cause mortar and brick to deteriorate and fall down - sometimes blocking or constricting the flue. In extreme cases, ice can actually form (usually at the top) and block off the flue.

Chimneys should be inspected from the clean-out doors as part of regular furnace servicing and as part of a pre-air sealing inspection by contractors. The symptoms of condensation in chimneys are:

- Debris at base of chimney, or at base of domestic hot water tank flue
- Efflorescence (white powder) on the exterior surface of the chimney. Water vapour passes through the brick, picks up salts and deposits them on the outside surface of the brick
- Water seepage or black stains from the clean-out doors
- Deteriorating brick work (masonry turns to powder).

Chimneys susceptible to condensation damage include the following cases:

- No chimney liner
- Improper flue size
- Decorative chimney cap
- Frequent cycling of furnance, or long "off" periods
- Oil to gas conversion.

If such problems exist, the remedial measures include:

- Installation of an approved metal chimney liner. Such a liner will heat up more rapidly than a masonry flue and will isolate any condensation that might occur from the brick
- Downsizing an oil furnace (generally after air sealing and insulation) by reducing nozzle size. This lengthens the burn time and reduces frequent on and off cycles which contribute to condensation
- Installation of an automatic flue damper which prevents warm moist air escaping up the flue when the furnace is off. (Note that this is not permissable in some provinces, such as Ontario, except where the damper is part of the original equipment or specifically approved.)

Section II: Assessment Procedures

CHAPTER 5. SELECTING THE BEST SEALING APPROACH PAGE 5.1

Chapter 5: Selecting the Best Sealing Approach

INTRODUCTION

A number of factors influence decisions about what sealing work to carry out in a given house.

To begin with, no two houses are alike from the point of view of sealing. The designs, age, quality of construction, materials, etc. will vary considerably. As a result, the relative importance of the various leakage openings will differ from house to house. In one house the foundation may be the main source of leakage; in another it may be the windows; in yet another it may be some construction defect, such as a missing firestop around a chimney.

Secondly, there are the complications that arise from existing or potential problems in the operation of the house. Typical examples are moisture problems in walls or roof spaces; poor air quality due to inadequate ventilation; excessive condensation damage around windows; deterioration of the foundation due to soil or water table effects; etc. In some cases these problems may be due to structural defects, and in some they may be due to occupant activities such as the generation of excessive amounts of moisture. Where a house has an obvious problem, related to air leakage, a good sealing job can reduce the seriousness of the problem at the same time as reducing heat losses. Conversely, the wrong sealing job may induce a structural problem where none existed previously.

It follows that each house has its own individual sealing requirements. It is no good sealing a foundation, for instance, if the windows are badly deteriorated and are obviously the main source of air leakage. Similarly, it is inadvisable to concentrate on sealing foundations, windows, and other accessible air leakage points if the main problem occurs in the attic. (In such a case, the sealing work will raise the humidity level in the house and will tend to increase the risk of moisture damage in the roof, due to exfiltration of moist house air into the roof space).

SEALING
APPROACH
continued

Therefore, the sealing contractor must conscientiously assess the sealing needs of each individual house, before selecting a sealing approach. If the house is assessed conscientiously in the first place, the subsequent sealing work will be more effective and there will be a better chance of avoiding long-term structural problems.

Assessment has three main elements:

. Identifying the main air leakage points

. Identifying any existing or potential problems that might be affected by sealing work

. Selecting an appropriate sealing "package" that is best suited to the specific needs and problems of the house.

The remainder of this chapter is divided into three sections dealing, in turn, with each of these three elements.

IDENTIFYING THE MAIN AIR LEAKAGE POINTS

As has been stressed, the importance of various air leakage points will vary considerably from house to house: no one case is completely "typical". Nevertheless, it is interesting to consider some of the research findings available. A study by the National Research Council of Canada, examining six 1950's houses, found the following ranges for component air leakage:

Ceilings 8-67%	Walls 15-77%
Doors/Windows 15-23%	Fireplaces 3-4%

To identify leakage points in a particular house, it is first important to know where to look. Such knowledge will come from experience, assisted by a careful study of the information in this Manual. In this regard, a useful aid for even experienced contractors is a "Leak Location Checklist".

A sample Checklist suitable for reproduction or adaptation is presented on the following two pages. It is intended to cover the major potential leak sites in each area of the house. By following this list and rating the importance of each leak site as it is inspected (see below), the contractor can be sure not to miss an area. The completed checklist will provide a useful record that will aid in cost estimating.

(The Leak Location Checklist presented on the following pages is accompanied by a sample "General Information Checklist" that contractors may also wish to use to record selected background information on each house that is to be sealed.)

LEAK LOCATION CHECKLIST	E-excellent S-satisfactory X-improvement needed XX-serious problem	LIVING AREA	KITCHEN	DINING ROOM	BEDROOM 1	BEDROOM 2	BEDROOM 3	BATHROOM 1	BATHROOM 2	FAMILY ROOM	LAUNDRY ROOM	BASEMENT	ATTIC LIVING AREA						
WINDOWS:	SASHES																		
	FRAMES																		
	MOULDING																		
	WEATHERSTRIPPING																		
EXTERIOR DOORS:	FRAMES																		
	MOULDING																		
	WEATHERSTRIPPING																		
	LEAKS THROUGH DOOR																		
LEAKAGE POINTS THROUGH THE CEILING:	ATTIC HATCH																		
	CHIMNEY																		
	CEILING FIXTURES																		
	PARTITION WALLS																		
	EXTERIOR WALLS																		
	PLUMBING STACK																		
	WIRING																		
	DUCTS																		
	EXHAUST FANS																		
	CEILING CRACKS																		
	DROPPED CEILING																		

LEAK LOCATION CHECKLIST continued	E-excellent S-satisfactory X-improvement needed XX-serious problem	LIVING AREA	KITCHEN	DINING ROOM	BEDROOM 1	BEDROOM 2	BEDROOM 3	BATHROOM 1	BATHROOM 2	FAMILY ROOM	LAUNDRY ROOM	BASEMENT	ATTIC LIVING AREA						
LEAKAGE POINTS THROUGH THE WALLS (INCLUDING FOUNDATION WALLS):	SWITCH COVERS																		
	OUTLET COVERS																		
	BASEBOARDS																		
	WALL CRACKS																		
	FIREPLACE/WALL JOINT																		
	TV CABLE																		
	BATHTUB/SHOWER																		
	MEDICINE CABINET																		
	EXHAUST FANS																		
	PLUMBING PENETRATIONS																		
	DRYER VENT																		
	SERVICE ENTRANCES																		
	WIRING TO OUTSIDE OUTLETS																		
	TOP OF FOUNDATION WALL																		
MISCELLANEOUS:	FIREPLACE DAMPER																		
	STAIR RISERS																		
	BASEMENT FLOOR DRAINS																		
	FLOORS OVER UNHEATED SPACES																		

GENERAL INFORMATION CHECKLIST

1. **HOUSE:** Year of construction ____________

Size ____________

Storeys ____________

General Condition ☐ tight ☐ average ☐ leaky

2. **INSULATION:** (approx. values)

Attics R______

Walls R______

Basement R______

________ R______

3. **HEATING SYSTEM TYPE:** ☐ oil ☐ gas ☐ electric ☐ wood ☐ __________

4. **HEAT DISTRIBUTION SYSTEM:** ☐ forced air ☐ hot water ☐ baseboard ☐ __________

5. **FIREPLACE:** ☐ yes ☐ no

6. **DOMESTIC HOT WATER HEATER:** ☐ electric ☐ gas ☐ oil ☐ __________

7. **EXHAUST SYSTEMS:**

	Location	CFM	How controlled?
☐	bathroom	____	______________
☐	kitchen	____	______________
☐	dryer	NA	NA
☐	house-vac	NA	NA
☐	__________	____	______________

GENERAL INFORMATION CHECKLIST (continued)

8. ARE ANY COMBUSTION DEVICES PROVIDED WITH AN OUTSIDE AIR SUPPLY?

☐ yes ☐ no

IF YES, WHICH ONE(S)? ______

9. DOES THE HOUSE HAVE A FRESH AIR INTAKE (such as a duct from outside to the furnace return air plenum)?

☐ yes ☐ no

IF YES, DESCRIBE ______

10. **QUESTIONS FOR THE HOUSEHOLDER:**

- Do you experience condensation on your windows in the winter months?

______

- Do you have frost in the attic?

______

- Have you had mould or mildew problems?

______

- How well does your fireplace draw?

______

- In which rooms do you experience cold drafts?

______

- What air sealing has been done to the house?

______

- What insulation work has been done in the house?

______

- Any other comments?

______

______

Knowing where to look is necessary but not sufficient. The contractor must be able to rate or assess the extent of leakage at each point. There are a number of ways of achieving this:

- A visual inspection is the most inexpensive way, but is not generally reliable since the visible gaps do not necessarily control the air leakage. For example, consider the case where the gap between a window frame and the surrounding wall is small and is concealed by a poorly-fitted casing. The gap around the casing may be large and seem important, but the critical air leakage gap is the much smaller gap between frame and wall. An experienced contractor will know where to look for possible air leakage - but will not always be able to determine the importance of each point.

- The homeowner can sometimes give help, by identifying the parts of the house where the largest drafts usually occur. Similarly, in winter, cold drafts are a useful indicator of large air leakage points. However, the exfiltration points are often as important as the infiltration points, but exfiltration is not easily identified by the draft method.

- The house can be depressurized by turning on all the household exhaust fans (including the clothes dryer) and turning on the furnace (which also draws air from the house and exhausts it up the chimney). All windows should be closed, and any opening that would allow air in, such as a fireplace damper, should be sealed with plastic and tape. The negative pressure created will increase the level of infiltration. A smoke pencil or a stick of incense (incense is less noxious) can then be used to locate areas of leakage. The speed of the smoke is an indication of the severity of the leak. Care should be taken to remove the plastic after completion of the work. CAUTION: If there is a possibility of insufficient combustion air being available to the furnace during this test, it is better to conduct the test with with the furnance off, in order to avoid exposing test personnel to hazardous conditions. In such houses, remedial measures to ensure a sufficient combustion air supply will likely be required. See Chapter 4.

- If the house has a forced air furnace with a fresh air intake connected to the cold air return, the circulating fan can be used to pressurize the house. First, all the return air registers in the house must be sealed with masking tape and plastic, and all exhaust vents must be shut off and sealed. A smoke pencil or incense can then be used to detect areas of air leakage (in this case, exfiltration).

- The most reliable method for identifying air leakage points is through an airtightness test, utilizing a door-mounted depressurization fan and instrumentation. Because this approach is effective, and because the test provides a number of other benefits, it is discussed separately below.

The Airtightness Test

To carry out an airtightness test, a sealed panel containing a powerful fan is mounted in the opening of one of the house's exterior doors. The fan depressurizes the house by exhausting air from the building. The fan can operate at various air flow rates, and has a series of instruments for measuring the flow rate and the resulting pressure difference between the inside and outside of the house.

The house is prepared for the test by sealing vents and flues, which contribute to the air leakage of the house but are not considered a part of the sealed house envelope. The fan is set to run at a particular speed. It exhausts air from the house and the pressure inside the house falls steadily. After two or three minutes the house pressure reaches a steady level. At this point, the rate at which the fan is exhausting air is exactly balanced by the rate at which air leaks inwards through the house envelope.

Compared to the normal situation, this inward leakage is greatly exaggerated, allowing easy identification of air leakage using smoke pencils or incense. This is not only useful in determining sealing priorities; it also serves as a powerful educational opportunity for contractors who are starting out in the sealing business.

In principle, this approach is very similar to the depressurization technique using household exhaust fans (discussed previously). However, the door fan can generally produce much greater infiltration, allowing for more reliable leak detection.

Furthermore, the door fan can not only give an indication of *where* the leaks are, but can also provide a measure of *how* leaky the house is. A series of measurements can be taken, recording the fan flow rate at various pressure differences between the inside and the outside of the building. The results are fed into a programmable calculator, which then calculates the airtightness level of the house. This airtightness level is presented in various ways; the recommended way is the Equivalent Leakage Area (ELA) which gives a rough indication of the total air leakage area in the house envelope. Air change rates per hour can also be calculated. Such information is valuable for at least four purposes:

- The measured airtightness of the house can be used by contractors to assess a target airtightness level for the sealing.

- Airtightness tests, conducted before and after the sealing work, give a contractor a good indication of the effectiveness of his sealing work.

- In cases where air quality is likely to be a problem after extensive sealing, the airtightness test will indicate the new level of airtightness of the house. From this, the need for additional ventilation can be assessed.

- Airtightness test results can also indicate the likelihood of a combustion air supply problem.

There is currently no requirement for contractors to use airtightness testing as part of the work covered in this Manual. However, because the benefits of the technique are considerable, **contractors should give serious consideration to the use of door fan equipment.**

IDENTIFYING EXISTING OR POTENTIAL PROBLEMS

As was noted in the introduction to this chapter, the specific location of important air leakage points is only one part of the information necessary before the contractor can decide what sealing work to do.

In addition, the contractor must determine whether any of a number of existing or potential problems are of concern in the house. The additional information is necessary because:

- The wrong sealing package can worsen some of these problems and/or create new problems
- The right sealing package can reduce the seriousness of some common house problems.

Table 5.1, beginning on the following page, identifies a number of structural and other house problems (existing or potential) that are likely to be of importance in air sealing work. **The table is a summary of information and recommended actions presented elsewhere in this Manual. Contractors should ensure that they evaluate carefully each of the items identified in the table, prior to selecting a sealing approach or package.**

Note: House problems tend to be seasonal, and the contractor may not always find the house in its worst state. If the house is assessed in summer, the contractor may miss condensation problems or air quality problems, as an example. The contractor should therefore make a point of questioning the householder regarding moisture damage, condensation, air quality, drafts, humidity, generation patterns, etc.

TABLE 5.1
PROBLEMS
CHECKLIST

☐ **Is there moisture damage in the walls?** (Refer to Chapters 2 and 10 for further background)	SYMPTOMS . Bubbled paint on the exterior siding . Odour in the house . Discolouration or fungus growth on the interior finished surface of the walls . Rust on drywall nails . Signs of corrosion inside electrical outlets in exterior walls . Mildew and dampness.
	CAUSES . The exfiltration of humid house air into the walls through various air leakage points, and/or . Rain penetration through the exterior siding.
	RECOMMENDED ACTION . Determine whether the problem is caused by exfiltration or by rain penetration, taking account of local climatic conditions and existing structural problems . If the symptoms are due to exfiltration then the sealing of air leakage points in the exterior walls will save energy and reduce the moisture damage problem.

TABLE 5.1
PROBLEMS
CHECKLIST (continued)

☐ **Is there moisture damage in the attic or roof space?**

(Refer to Chapters 2 and 11 for further background)

SYMPTOMS

- Discolouration of the ceiling finish
- Sag of the ceiling plasterboard, with nail pull-off or rusting around nail neads
- Discolouration of roof sheathing, or water marks on the roof framing members
- In winter: frost or condensation on the sheathing and framing members
- Signs of water damage on insulation.

CAUSES

- Rainwater penetration due to defective roof materials or installation, and/or
- The exfiltration of humid house air into the attic/roof space. Note that the level of ventilation provided in the attic/roof space influences the likelihood of problems due to exfiltration. In some instances there may be excessive exfiltration air leakage into the space, but if there is adequate ventilation there may be no serious moisture damage. See discussion in Chapter 11.

RECOMMENDED ACTION

- Determine whether the problem is caused by exfiltration or rain penetration. Note that in some cases the signs of moisture damage may be very old, and may be due to rainwater leakage through a defective roof covering several years previously. In such cases, the contractor can benefit from the knowledge of the householder regarding past repair work.

TABLE 5.1
PROBLEMS
CHECKLIST (continued)

	. If the symptoms are due to exfiltration, determine whether or not the roof or attic cavity is adequately ventilated. Is there adequate ventilation at soffits, gables, roof slope, etc.? Have the ventilation channels been blocked by insulation? In winter, are the vents blocked by ice? If the ventilation is inadequate, improvements should be made (though this work is not a part of the sealing task). . Generally, where mositure damage occurs in an attic or roof space as the result of exfiltration, a high priority should be assigned to the sealing of air leakage points in the ceiling.
☐ **Is there moisture damage at the top of foundation walls?** (Refer to Chapter 8 for further background)	SYMPTOMS . Discolouration of the wood structure where it joins the top of the foundation wall . In winter, condensation or frost build-up on the wood frame at the top of the foundation wall . Dry rot, fungus, or mildew on the wood frame.
	CAUSES . The most likely cause is moisture movement through the foundation wall, by "wicking". The effect tends to be stronger in foundation walls that have mortar in their construction, such as unit masonry or stone walls.
	RECOMMENDED ACTION . When this problem is encountered, it is generally inadvisable to seal the area at the top of the foundation wall. There are two reasons:

TABLE 5.1
PROBLEMS
CHECKLIST (continued)

	first, it is unlikely that a good seal could be maintained around the defective woodwork; second, the air leakage at this point helps to control excessive moisture build-up. Because sealing will tend to reduce the air leakage, it could cause accelerated moisture damage. . In general, proceed with caution. It is recommended that contractors draw the attention of the householder to the problem and explain that remedial measures should be conducted before sealing.
☐ **Is there excessive condensation on windows?** (Refer to Chapters 3 and 12 for further background)	SYMPTOMS . Water damage of the window frame, particularly on the sill . Water damage on the wall finish around the window unit . In winter, large accumulations of frost or condensation on the window panes.
	CAUSES . Excessive humidity levels in the house and/or inadequate thermal resistance of the windows . In multi-layer windows, such as double or triple slider units, signs of condensation between the various layers of glass are an indication of air exfiltration.

SEALING
APPROACH
continued

TABLE 5.1
PROBLEMS
CHECKLIST (continued)

RECOMMENDED ACTION

- Determine whether the problems are caused by excessive humidity levels in the house, by poor thermal resistance of the window units, by air exfiltration, or by combinations of these.
- If the problem is caused by excessive humidity generation in the house, proceed with caution when selecting a sealing package. Any sealing work will tend to decrease the air movement through the house, and this will lead to higher humidity levels. In turn, these could create a range of moisture damage problems. (Some obvious signs of excessive humidity generation are the need for one or more dehumidifiers; the venting of dryers into the house; large families with several small children; large numbers of house plants; and modifications intended to give increased ventilation of the house.)
- If the problem is caused by poor thermal resistance of the window (single pane, poor outer storm, etc) it is advisable to upgrade the window.
- If the problem is caused by air exfiltration in multi-pane windows, improved weatherstripping should be installed.

TABLE 5.1
PROBLEMS
CHECKLIST (continued)

	DISCUSSION

☐ **Is there a potential problem regarding adequate air supply for combustion appliances? Is there a potential problem regarding interaction between combustion appliances and exhaust vent systems?**
(Refer to Chapter 4 for further background)
	. Combustion appliances include combustion furnaces; combustion hot-water heaters; fireplaces; woodstoves; gas stoves; free-standing kerosene heaters; etc.
	. Exhaust vent systems include bathroom vents, kitchen vents, dryer vents, and vents for central vacuum cleaner systems.
	. Where combustion appliances draw the air they need for combustion and draft from the house (the usual case), a sealing job that achieves a high level of airtightness may result in air supply problems to the appliance (since the house depends on infiltration to replenish the combusion and draft air). If this happens, the combustion appliances will compete strongly with each other and with the exhaust vent systems in the house. This may result in various hazards or air quality problems. For instance:
	  . A combustion furnace may cause a smoldering wood stove or fireplace to backdraft (i.e. draw air down the chimney, introducing smoke and harmful combustion products into the house air)
	  . Conversely, a wood stove or fireplace may cause a furnace to backdraft, drawing the harmful flue gases into the house
	  . A furnace may cause the vent above a cooking stove to backdraft, resulting in odour build-up and, in the case of a gas stove, entry of harmful combustion products into the house.
	  . A bathroom, range, or dryer exhaust vent may cause combustion appliances to backdraft.

TABLE 5.1
PROBLEMS
CHECKLIST (continued)

RECOMMENDED ACTION

- **Where a house is to be sealed to a high level of airtightness, it may be essential to provide the house with an improved air management system that provides enough air to avoid problems related to combustion air supply**
- It is strongly recommended that the contractor educate the householder on the problems that might arise; on the necessary remedial measures; and on the associated costs. **It is further recommended that, after the sealing work has been completed, the contractor ensure that no air supply problem has developed.**
- (Where there are high levels of airtightness, the combustion air supply problem is compounded by air quality problems, as discussed below. Remedial measures must therefore be adopted for both problems).

☐ **Is the house electrically heated?**

(Refer to Chapter 2 for further background)

DISCUSSION

- Where houses are electrically heated and have no combustion appliances of any type, there is generally less air leakage through the envelope than in the case of an oil, gas, or wood heating system (since the air supply needs of most of these combustion units are met by, in effect, drawing outside air through the envelope into the house)
- As a result, electrically heated houses tend to have higher levels of humidity and a higher proportion of their air leakage is exfiltration (notably over the upper half of the house)
- The combined exfiltration and higher humidity produce a greater risk of moisture damage in attics, roof spaces, and exterior walls (when compared to houses heated with a combustion system).

TABLE 5.1
PROBLEMS
CHECKLIST (continued)

	RECOMMENDED ACTION . When a house has no combustion heating appliances, give priority to sealing the upper parts of the house envelope at the ceilings and exterior walls.
☐ **Is there a potential problem regarding indoor air quality?** (Refer to Chapter 3 for further background)	DISCUSSION . The air inside a house contains a wide range of materials that impair its quality, as was outlined in Chapter 3. Some of these pollutants have health effects. . Safe concentrations of the various pollutants depend upon the material in question, and sometimes depend on the individual sensitivities of the house occupants. For example, some people are far more sensitive to formaldehyde than others. . The level of a pollutant in house air is determined by two factors: the rate at which it is generated and the rate at which it is removed by air leakage. The higher the air change rate, the lower the pollutant concentration. Since sealing work is designed to reduce the air exchange rate, it therefore tends to cause a general increase in pollutant levels, with a consequent decrease in air quality. In some cases, where high levels of airtightness are achieved, the air quality may become unacceptable. . Radon infiltration is an exception to this general situation. The rate of radon generation is high in some soils. The radon is carried into the house by infiltration. Air flows through the soil, picking up radon on the way, and then enters the house through the floor

TABLE 5.1
PROBLEMS
CHECKLIST (continued)

drain or through cracks in the foundation. It follows that radon infiltration can be reduced by sealing cracks in the foundation wall.

RECOMMENDED ACTION

- Where the house already has a poor air quality, in the form of excessive humidity levels, odour, or pollutant concentrations, any sealing will tend to worsen the problem, and should not be conducted without some parallel attempt to improve the ventilation system of the house.
- Where the house initially has adequate air quality, but is to be sealed to a high level of airtightness, it is possible that this will create an air quality problem. If so, it will be necessary to install some kind of remedial ventilation system.
- (Where there are high levels of airtightness, the air quality problem is compounded with problems of combustion air supply, as mentioned earlier. Remedial measures must therefore be adopted for both problems.)
- At the present time it is impossible to give firm guidance to contractors on how to ensure good air quality and adequate combustion air supply. The problem has too many variables and has not been studied to any great extent (though several projects are currently considering these issues). However, **it is important for contractors to understand the potential hazards.** Refer to Chapters 3 and 4.
- With regard to the special case of radon, some areas are known to have soils with high rates of radon emission. Contractors should acquaint themselves with any radon problems in their area, and should give a relatively high priority to foundation sealing where there is a radon problem.

TABLE 5.1
PROBLEMS
CHECKLIST (continued)

☐ **Are there foundation cracks?**

(Refer to Chapter 8 for further background)

DISCUSSION

- The majority of Canadian residences have foundations consisting of a full basement made of concrete, unit masonry, or stone. These usually display cracks of varying sizes in both the foundation walls and the floor slab. Because air can move through soil fairly easily, even a foundation crack below grade may still be a major source of air infiltration.

- The cause of cracking is important when deciding whether to seal the cracks or not. In some instances the cracking may have occurred during the first six months of construction, and may have stabilized over a period of several years. Any sealing applied to such cracks will probably maintain a tight seal for several years. On the other hand, the crack may be "active" due to the effects of the water table, soil movement, climatic variations, etc. If the crack movement is small, it may be possible to achieve a durable seal. But if the crack movement is large, even the best grouts may fail within a matter of a few years or months.

RECOMMENDED ACTION

- Where possible, determine the cause of cracking, and try to assess the possibility of further crack movement. This will require considerable experience on the part of the contractor

- If little or no crack movement is anticipated, the cracks can be sealed

- Where large crack movement is anticipated, major repairs are recommended

TABLE 5.1
PROBLEMS
CHECKLIST (continued)

	. As discussed above, where radon infiltration is a problem, priority should be given to foundation sealing.

SELECTING AN APPROPRIATE SEALING PACKAGE

As has been stressed, each house has its own, specialized, sealing needs. Based on a complete inspection of the house (and on an airtightness test, if conducted) the contractor should know:

- The major points of air leakage in the structure (and the existing level of airtightness), plus
- The nature and extent of existing problems, together with an understanding of how various sealing strategies might reduce or worsen these problems.

With this assessment information, the contractor is in a good position to select a customized sealing approach. The goal is to choose an effective, energy saving package that will avoid new problems while, perhaps, helping to correct existing ones.

The contractor is solely responsible for the selection of a sealing package. As one part of this responsibility, the contractor must identify any remedial action that might be required as a result of the sealing work proposed. Specifically, the contractor must identify potential air quality and air supply problems that require attention. Ensuring that a house does not experience such problems (either by limiting the amount of sealing to be carried out or by making provision for controlled ventilation and for combustion air supply) is a central element in the selection of an appropriate sealing package. (An airtightness test is a particularly useful tool in ensuring that ventilation remains adequate.)

As an aid to contractors in the selection process, this chapter presents two tables in the following pages. Table 5.2, An Overview of Sealing Measures, identifies a number of characteristics or criteria for quality sealing work.

SEALING
APPROACH
continued

The sealing work referred to is confined to relatively simple and direct methods, and excludes techniques that require major structural changes (i.e. changes involving costs of $500 or more, in addition to the costs of the sealing work).

**TABLE 5.2
AN OVERVIEW OF
SEALING MEASURES**

Scope	This overview identifies a set of guiding principles for the air sealing work described in this Manual and, specifically, for the work packages identified in Table 5.3.
Existing conditions	Where the existing condition of the house envelope, or part of the house envelope, is defective and will not allow an effective and durable seal, sealing work should not be conducted until the defective area has been repaired satisfactorily. Where such problems are encountered, the contractor should explain the requirements to the homeowner and should allow the homeowner to decide whether or not repairs are to be conducted, at a cost over and above the cost of sealing.
Limitations on crack sealing	Sealing work should be conducted on cracks only where the crack is a source of air leakage through the building envelope, and only where the crack is wider than 0.8mm (the approximate thickness of a putty knife) over more than 10% of its length.
Limitations on weatherstripping	Weatherstripping should be installed or replaced on doors, openable window sections, hatches, and other openable facilities in the house envelope, if there is a detectable air gap extending for more than 10% of the perimeter of the openable section. For the purpose of this Manual, a detectable crack is defined as one having a width greater than 0.8mm.

TABLE 5.2
AN OVERVIEW OF
SEALING MEASURES (continued)

Surface preparation for sealants	When sealant is to be applied to a crack or structural joint, the working surfaces should be properly cleaned and primed in accordance with good sealing practice, and according to the requirements of the sealant being used. This also applies to the use of grouts on concrete and masonry walls.
Sealant application	Sealant should be applied to cracks in accordance with good sealing practice, in such a way that the seal will remain effective for at least ten years on non-moving cracks or joints. On completion, the seal should not have gaps greater than 0.8mm over more than 10% of the length of the sealed crack. Gaps that are individually wider than 0.8mm, or longer than 10% of the sealed crack, should be regarded as sub-standard.
Conditions during sealing	When a sealant is being applied, the working surfaces should have the proper levels of dryness, as required for the sealant being used, and should not be at a temperature lower than the required working temperature of the sealant.
Sealant materials	The selected sealant material should be suitable for the working surfaces to which it is applied, and should be of a type that will maintain a durable seal for at least 10 years.

TABLE 5.2
AN OVERVIEW OF
SEALING MEASURES (continued)

Surface preparation for weatherstripping	Surfaces to which weatherstripping is to be attached should first be cleaned and smoothed so as to permit good airtight seals.
Weatherstripping application	Weatherstripping should be applied so as to make a continuous airtight seal around an openable section. For the purposes of quality control, gaps of 1.0mm are allowable at corner joints between weatherstripping, but there should be no detectable gaps along the individual sections of weatherstripping. Where there is likely to be a gap between weatherstripping and the surface to which it is applied, a bed of sealant should be applied first along the working surface, so as to seal the gap when the weatherstripping is in place.
Selection of weatherstripping type	The selected weatherstripping should be the most economical available, subject to the following requirements: first, it should be made of materials that will maintain a good seal for ten years under the prevailing conitions of temperature and sunlight, subject to normal wear and tear; second, the type of weatherstripping should be such that it will maintain a good seal under normal warping and deformation of the sealed opening.
Associated hardware	Where necessary to maintain a proper sealing action of weatherstripping, the openable section should be provided with suitable hardware.

TABLE 5.2
AN OVERVIEW OF
SEALING MEASURES (continued)

Code requirements	In areas where sealing materials are likely to constitute a fire hazard or an electrical safety hazard, the selected materials should satisfy the fire codes, electrical codes, and other standards, as applicable. This also applies to the use of gasket material and other sealing devices that are used around electrical facilities.
Toxicity	Within the envelope of the house, the contractor should not use sealants or other materials that are specifically labelled for exterior use only, or that are identified as containing hazardous materials.
Finishing	On completion of all sealing work, the working surfaces should be left in good condition. Any surplus exposed sealant should be removed. Where the sealing work involved damage to the existing surfaces, casing, etc., the damaged areas should be repaired and finished to match the surrounding surfaces (unless otherwise instructed by the householder).
Clean up	On completion of the work, the contractor should remove from the site all materials, equipment, and waste used or produced as part of the sealing work.

The next (and final) table in this chapter is also intended to aid contractors in the selection of a sealing package. Table 5.3, Air Sealing Packages: Seven Examples, presents possible approaches for certain, specific situations.

Packages 1-6 are moderate cost options, each one roughly comparable in cost to the others. They are suitable for situations where the householder does not wish to invest in a more comprehensive, more expensive, and more disruptive job. In most situations, the level of sealing described will not create an air quality problem (though contractors should confirm this on a case-by-case basis).

Where there is a cost limit, contractors should obviously concentrate on those options that will be of maximum benefit - and the choice regarding maximum benefit will be heavily influenced by the character of any existing problems. Thus, Packages 1-6 focus on certain specific and relatively common problems. "Primary" sealing measures are presented: these represent a minimum response to the identified problem. "Secondary" measures are also identified: these can cost-effectively cut air leakage, but are not generally necessary to deal with the identified problem.

Package 7 represents a comprehensive sealing package, substantially more involved than the others. Because of its comprehensive character, it is described in more detail than Packages 1-6. Note that such a comprehensive sealing job may reduce the air exchange in the house to a point where it is necessary to undertake specific remedial measures to provide adequate air quality control and adequate air supply for combustion units.

Contractors should exercise extreme caution in referring to these packages. They are examples, not prescriptions. Because every house represents a unique situation, the contractor must assess each house as described earlier in this chapter. Once the assessment is complete, the contractor can identify his/her own package. Comparison of this package to the packages presented in Table 5.3 (specifically, to the package(s) addressing the same problem(s) as the contractor has identified) can provide a valuable cross check. To repeat however, **assessment is the responsibility of the contractor and must be specific to each individual house.**

TABLE 5.3 AIR SEALING PACKAGES: SEVEN EXAMPLES

PACKAGES 1-7	NOTE 1. The sealing packages presented in this table are examples, not prescriptions. Refer to the main text. 2. In addition to the sealing measures listed as a part of each package, two other measures are of general applicability. First, it is strongly recommended that any recessed light fixtures in the ceiling be replaced by conventional non-recessed units (or simply be removed and the opening sealed). Second, where exhaust vents are ducted into the attic or roof space, it is strongly recommended that the ducting be modified to vent to the outside, above the roof (if possible). 3. **All work should be carried out in accordance with the characteristics presented in Table 5.2 (Overview of Sealing Measures).** Specific techniques are presented in Chapters 6-13 of this Manual.
PACKAGE 1: For possible use in houses with moisture problems in an accessible attic/ roof space, where heat is supplied by a combustion appliance	EXPLANATION Moisture problems in attics or roof spaces may or may not be caused by exfiltration of moist house air into these areas. The following work should be done only if the problems can be traced to exfiltration, or where the cause of the problem is uncertain. This package concentrates on the sealing of the air leakage points in the upper part of the house envelope. The work should be done from inside the attic or roof space.

TABLE 5.3
AIR SEALING
PACKAGES:
SEVEN
EXAMPLES (continued)

PRIMARY SEALING MEASURES

Seal the following points:

1. Tops of all partition walls that have no top plate
2. Gaps around chimneys
3. All ceiling electrical receptacles
4. Gaps around plumbing stacks
5. Gaps around exhaust ducts or heating ducts where they pass into the attic
6. Gaps around electrical cables where they pass into the attic
7. Attic hatch
8. Gaps at the edge where the exterior wall joins to the ceiling drywall, if there is good access
9. All joints in any heating ducts that are routed through the attic or roof space.

SECONDARY SEALING MEASURES

Seal the following points:

1. Tops of partition walls that have continuous top plates, if there is good access

TABLE 5.3
AIR SEALING
PACKAGES:
SEVEN
EXAMPLES (continued)

	2. All electrical outlets and all switches in exterior walls 3. Any gaps or cracks in the drywall of the ceiling and exterior walls.
PACKAGE 2: For possible use in houses that have moisture problems in an inaccessible attic or roof spaces	EXPLANATION Where there is a moisture problem in an inaccessible attic or roof space, the sealing work should be concentrated on the accessible parts of the various air leakage paths that are coupled to the attic or roof space. This package concentrates on such points.
	PRIMARY SEALING MEASURES Seal the following points: 1. All electrical receptacles in the ceiling 2. Gaps around the chimney (where it passes through the ceiling if accessible, or in the basement if not accessible at the ceiling) 3. Gaps around the plumbing stack, working in the basement 4. All electrical receptacles in exterior and partition walls 5. All gaps between bottom plates and the subfloor, on exterior and partition walls

TABLE 5.3
AIR SEALING
PACKAGES:
SEVEN
EXAMPLES (continued)

	6. All gaps between interior door frames and the surrounding partition walls 7. All drywall gaps or cracks. Note: Sealing gaps in partition walls is intended to reduce "indirect" air leakage. See Chapters 10 and 11.
	SECONDARY SEALING MEASURES Seal the following points: 1. All gaps between window frames and the surrounding wall 2. All gaps between exterior door frames and the surrounding wall.
PACKAGE 3: For possible use in houses with moisture problems in the exterior walls, where heat is supplied by a combustion appliance	EXPLANATION Moisture problems may or may not be caused by the exfiltration of moist house air into the walls. Before proceeding with the following work, the contractor must first ensure that the wall moisture problems are caused by exfiltration (as opposed to rain penetration). This package concentrates on sealing air leakage openings in the exterior walls, with supplementary sealing at other parts of the house envelope.

TABLE 5.3
AIR SEALING
PACKAGES:
SEVEN
EXAMPLES (continued)

PRIMARY SEALING MEASURES

Seal the following points:

1. All electrical receptacles (outlets, switches, lights) in exterior walls
2. Gaps between window frames and the surrounding wall
3. Gaps between the frames of exterior doors and the surrounding wall
4. Gaps between the bottom plate and the subfloor at the exterior wall, where there is good access
5. Any cracks or gaps in the drywall of the exterior walls
6. Any accessible penetrations (cables, pipes, ducts, etc.) in the exterior walls.

SECONDARY SEALING MEASURES

Seal the following points when the attic or roof space is accessible:

1. Tops of all partition walls that have no top plate
2. Gaps around chimneys
3. Electrical receptacles in the ceiling
4. Attic hatch.

SEALING
APPROACH
continued

TABLE 5.3
AIR SEALING
PACKAGES:
SEVEN
EXAMPLES (continued)

	Seal the following points when the attic or roof space is inaccessible: 1. Air leakage points at ceiling fixtures 2. Gaps around chimneys (at ceiling level where accessible, or in the basement if not accessible at the ceiling) 3. Gaps around the plumbing stack (working in the basement).
PACKAGE 4: **For possible use in houses with an electrical heating system only (ie with no combustion heating system and no fireplace)**	EXPLANATION Since there is no chimney in electrically heated houses, there is no chimney effect to draw down the house pressure and resist the outward movement of moist air into the structure. In such houses there is a high risk of structural moisture damage. This package is directed at the main air leakage points that are responsible for this damage. In electrically heated houses, the infiltration rate typically is relatively low. There is therefore a risk of sealing the house too tightly - to the point where air quality problems may arise. For this reason, continued infiltration is allowed in the basement and through parts of the door and window systems.

TABLE 5.3
AIR SEALING
PACKAGES:
SEVEN
EXAMPLES (continued)

PRIMARY SEALING MEASURES

Seal the following points when the house has an accessible attic:

1. Tops of all partition walls that have no top plate
2. All ceiling electrical receptacles
3. Gaps around plumbing stacks
4. Gaps around exhaust ducts or heating ducts where they pass into the attic
5. Gaps around electrical cables where they pass into the attic
6. Attic hatch
7. Gaps at the edge where the exterior wall joins to the ceiling drywall, if there is good access
8. All joints in any heating ducts that are routed through the roof space or attic
9. Electrical receptacles in exterior walls
10. Gaps between window frames and the surrounding wall
11. Gaps between exterior door frames and the surrounding wall.

Seal the following points when the house has an inaccessible attic or roof space:

1. All electrical receptacles in both interior and exterior walls

TABLE 5.3
AIR SEALING
PACKAGES:
SEVEN
EXAMPLES (continued)

2. Gaps between door frames and the surrounding wall, on both exterior and interior doors
3. Gaps between window frames and the surrounding wall
4. All ceiling electrical receptacles
5. All accessible bottom plates on all walls (exterior and partition)
6. All cracks and gaps in drywall
7. Gaps around the plumbing stack (working in the basement).

NOTE: Sealing gaps in partition walls is intended to reduce "indirect" air leakage. See Chapters 10 and 11.

SECONDARY SEALING MEASURES

None presented

PACKAGE 5: For possible use in houses that are located in areas with a high radon emission rate in the soil

EXPLANATION

When soils have high emission rates of radon gas, this infiltrates into the house through various openings in the foundation and floor slab, and may cause an air quality problem. This package is directed at the main potential radon entry points.

TABLE 5.3
AIR SEALING
PACKAGES:
SEVEN
EXAMPLES (continued)

In houses where the foundation walls and floor slab are concealed by developmental work (ie a finished basement), and where access to the foundation and floor slab would involve large structural changes and high costs, it is most strongly recommended that no sealing work be done on any part of the house envelope. Note that this restriction only applies where there is a known or suspected radon problem, and where the foundation and floor slab cannot be sealed by direct, low-cost methods.

PRIMARY SEALING MEASURES

1. Seal all cracks in the foundation wall and floor slab
2. If the floor drain does not have a solid metal cover, install such a cover (or advise the householder to pour a bucket of water into the floor drain each week, so as to keep the trap full).

SECONDARY SEALING MEASURES

Seal the following points:

1. All electrical receptacles in the exterior walls and ceiling
2. Gaps between window frames and the surrounding wall
3. Gaps between door frames and the surrounding wall

TABLE 5.3
AIR SEALING
PACKAGES:
SEVEN
EXAMPLES (continued)

	4. All drywall cracks and gaps 5. Gaps between bottom plates and the subfloor 6. Attic hatch. **If there are no significant gaps to be sealed in the foundation wall and slab,** also undertake the general attic sealing measures given in Package 1.
PACKAGE 6: **For possible use in houses that have no identifiable problems, where a moderate level of sealing is to be carried out**	EXPLANATION This package provides an example of a moderate cost sealing option that is only suitable for houses with no identifiable sealing -related problems (see Table 5.1). The package presented is relevant to houses with a fairly normal air leakage pattern (i.e. no excessive air leakage points that stand out above the others). If an airtightness test shows a particular leakage point is more important than the others, the sealing measures presented below remain relevant, but priority should be given to the major leakage points.

TABLE 5.3 AIR SEALING PACKAGES: SEVEN EXAMPLES (continued)

PRIMARY SEALING MEASURES

Seal the following points:

1. Tops of all partition walls that have no top plate
2. Gaps around chimneys in the attic or roof space
3. All ceiling electrical receptacles
4. Attic hatch
5. Electrical receptacles in exterior walls
6. Gaps between window frames and the surrounding wall (including basement windows)
7. Gaps between exterior door frames and the surrounding wall
8. Gaps between exterior doors and the door frame (weatherstripping required)
9. Gaps in the header area at the top of foundation walls, where easily accessible.

SECONDARY SEALING MEASURES

Seal the following points:

1. Openable sections of windows (weatherstripping required)
2. All drywall cracks and gaps
3. Gaps between the bottom plate and subfloor on all exterior walls

TABLE 5.3
AIR SEALING
PACKAGES:
SEVEN
EXAMPLES (continued)

4. Gaps between floor sections that pass under the bottom plate to the exterior
5. All cracks in the foundation wall and floor slab, where accessible.

PACKAGE 7:
For possible use in houses where a comprehensive "whole-house" sealing job is to be carried out

EXPLANATION

This package provides an example of a comprehensive and relatively high cost level of sealing. The revelant measures are separately identified below, in some detail, for each component of the house.

The existence of structural problems, such as those identified in Table 5.1, does not generally preclude the adoption of a comprehensive approach, but may preclude the implementation of certain specific measures. Some of the most important of these exclusions are noted below as "Limitations". More generally, **the degree of airtightness that results from comprehensive sealing will, in some cases, require remedial measures for air quality and combustion air supply**.

This example package is comprehensive, but it is not a maximum. For instance, as is noted below (again under "Limitations") the package does not call for sealing in many areas where access is difficult. In addition, this comprehensive package does **not involve** all of the sealing techniques presented in this Manual. Often, it may be desirable to implement some of these other measures in addition to, or instead of, some of the measures noted below.

TABLE 5.3
AIR SEALING
PACKAGES:
SEVEN
EXAMPLES (continued)

WINDOWS

The following work should be carried out:

1. Seal the gaps between the window frame and the surrounding wall surface. As an alternative, the gaps between the interior trim and the frame and between the interior trim and the surrounding wall can be sealed.

2. Seal the gaps between any permanently fixed window sashes and the window frame.

3. Seal structural joints in the window frame.

4. Replace any defective putty or sealant at the joint of the sash and the window glass, but only where this is likely to constitute an air leakage opening.

5. Replace any defective weatherstripping or install new weatherstripping where there are gaps around openable sections of window.

6. Adjust or replace, as required, existing closure hardware (sash locks, etc), if necessary to maintain a good weatherstrip seal.

7. Seal any air leakage gaps around the window hardware.

Limitations:

1. Storm windows need not be weatherstripped or sealed as described above, unless the main window unit is single-glazed and there is extensive evidence of condensation on the interior unit.

TABLE 5.3
AIR SEALING
PACKAGES:
SEVEN
EXAMPLES (continued)

2. The above work applies only to windows that make up part of the warm air enclosure of the living space. Garage windows are excluded, whether the garage is heated or not. The same applies to solariums or similar additions outside the main warm air enclosure of the house.

3. On multiple slider units, weatherstripping should be applied only to the interior glazing units (unless the exterior units were originally weatherstripped, in which case the original seals may be replaced if necessary).

DOORS

The following work should be carried out:

1. Seal the gaps between the door frame and the surrounding wall surface. A less desirable alternative is to seal the gap between the frame and the casing, and the gap between the casing and the wall.

2. Seal the gap between the door sill and the floor.

3. Seal any structural joints in the door frame that are sources of air leakage.

4. Replace existing weatherstripping or install new weatherstripping on doors, as required.

5. Adjust lock sets and door stops or re-hang the door, if required to maintain a good weatherstrip seal.

TABLE 5.3
AIR SEALING
PACKAGES:
SEVEN
EXAMPLES (continued)

Limitations:

1. The above measures apply only to doors that make up part of the warm air enclosure of the house.

BASEBOARD AREA

The following work should be carried out:

1. Seal gaps between the baseboard and the floor, and between the baseboard and the wall. An alternative is to remove the baseboard and seal the gap between the bottom plate and the floor.
2. Where the floor structure has cracks or structural joints that run under the exterior wall, these should be sealed as close to the baseboard or bottom plate as possible.

Limitations:

1. This work should be restricted to baseboards on exterior walls, and to sections of this baseboard that are easily accessible. Inaccessible areas include those that are concealed by baseboard heaters, radiators, etc.

ACCESSIBLE ATTICS AND ROOF SPACES

The following work should be carried out if the contractor has reasonable access to the attic or roof space:

1. Seal gaps between the top plates of partition walls and the ceiling, and between the top plates of exterior walls and the ceiling, where reasonably accessible.

TABLE 5.3
AIR SEALING
PACKAGES:
SEVEN
EXAMPLES (continued)

2. Where there are wall cavities that open into the attic space, block these off and seal.
3. Construct an airtight enclosure around all electrical fixtures protruding through the ceiling.
4. Seal around electrical cables where they pass through the top plates of partition walls or through the ceiling.
5. Construct an airtight enclosure around chimneys, using materials and clearances that conform to the prevailing fire codes.
6. Seal around all vents, stacks, and ducts where they pass through the partition wall top plate or ceiling.
7. Where heating ducts are routed through the attic or roof space, seal all duct joints and ensure that there is a good fill of insulation around all sides of the ducts.

CEILINGS WITH INACCESSIBLE ATTICS OR ROOF SPACES

The following work should be carried out on ceilings that make up the top surface of the warm air envelope of the house, and have inaccessible spaces above them. The work may also be applied to ceilings on intermediate floors where there is no convenient way of sealing around the floor headers:

1. Seal any gaps in the ceiling finish.
2. Seal any corner gaps between the ceiling and the walls.

TABLE 5.3
AIR SEALING
PACKAGES:
SEVEN
EXAMPLES (continued)

3. Seal around all accessible penetrations of the ceiling, including vents, chimneys, ducts, pipes, cables, etc.
4. Seal air leakage gaps, where possible, on the exposed parts of ceiling light fixtures.

EXTERIOR WALLS

The following work should be carried out:

1. Seal all cracks in the interior wall finish.
2. Seal all gaps where the exterior wall meets the ceiling or partition walls.
3. Install gaskets and childproof plugs on all electrical outlets in exterior walls.

Limitations:

1. The above work applies to exterior walls that make up part of the warm air envelope of the house. It does not apply to exterior garage walls, verandah walls, etc.

FOUNDATIONS (full basement type)

The following work should be carried out:

1. Where the foundation walls and the floor slab have large cracks, seal these individually.
2. Where the foundation has an intensive pattern of small cracks, seal using a general surface cover.

TABLE 5.3
AIR SEALING
PACKAGES:
SEVEN
EXAMPLES (continued)

3. Seal all gaps between basement window frames and the surrounding wall.

4. Treat any exterior doors in the basement as noted above for doors.

5. Seal all air leakage gaps in the area of the floor header at the top of the foundation wall.

Limitations:

1. Crack sealing in foundation walls should not be conducted where there is reason to believe that the crack will continue to display large movement. In this case, contractors should alert homeowners to the need for good repair work.

2. Header sealing should not be conducted if there is evidence of extensive moisture accumulation at the top of the foundation wall. In this instance contractors should alert the homeowner to the problem and to the need for repairs.

3. Header sealing and crack repair should be conducted only where there is reasonably good access to the problem areas, without requiring major structural damage or modification. Where the basement has a suspended ceiling with tiles that can be removed and replaced easily, this is considered to provide reasonable access.

FLOORS OVER UNHEATED SPACES

The following work should be carried out:

1. Seal baseboards or bottom plates as specified above for the baseboard area.

TABLE 5.3
AIR SEALING
PACKAGES:
SEVEN
EXAMPLES (continued)

2. Seal all cracks or gaps in the floor structure, where accessible. As an alternative, if the floor contains a large number of gaps, and is accessible, the sealing can be conducted by installing a polyethylene vapour barrier.
3. Seal all vent stacks, pipes, ducts, cables, etc. where they pass through the floor and are accessible.

SERVICE AND UTILITY ENTRANCES AND OTHER PENETRATIONS

The following work should be carried out:

1. Seal the gaps around the following features, where they pass through the house envelope:
   - Electrical service conduit
   - Cable exits to exterior outlets
   - Water entry pipe
   - Oil pipe entries
   - Gas service entries
   - Exhaust vents (dryer, house-vac, etc.)
   - Waterpipe to outside faucet.

   This sealing must be done, as far as possible, on the warm side of the house envelope.
2. Seal air leakage gaps on the interior of the electrical service conduit, using an approved sealant.

Limitations:

1. The above work should be conducted only where there is easy access to the working area.

Section III: Air Sealing Practices

CHAPTER 6. INTRODUCTION TO AIR SEALING PRACTICES PAGE 6.1
CHAPTER 7. MATERIALS AND THEIR APPLICATION PAGE 7.1
CHAPTER 8. FOUNDATIONS PAGE 8.1
CHAPTER 9. FLOORS OVER UNHEATED SPACES PAGE 9.1
CHAPTER 10. EXTERIOR WALLS PAGE 10.1
CHAPTER 11. ATTICS AND ROOF SPACES PAGE 11.1
CHAPTER 12. WINDOWS PAGE 12.1
CHAPTER 13. DOORS PAGE 13.1

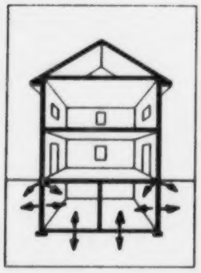
Chapter 6: Introduction to Air Sealing Practices

OVERVIEW OF SECTION III

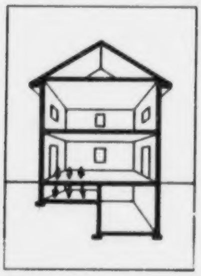
Section II of this Manual addressed the question of **what** sealing work to do in a given house. This Section III describes **how** to do it.

The following pages present detailed information on the most important sealing techniques available for use in low-rise residential buildings. The material is organized into seven chapters.

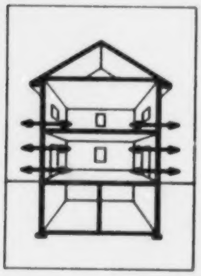
Chapter 7 discusses the relative merits of various sealants, weatherstrips, and other products used in air sealing work. Chapters 8-13 cover **specific** techniques for each major part of the house exterior:



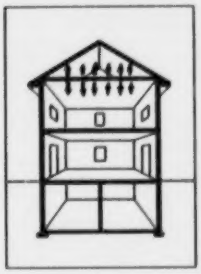
FOUNDATIONS . . . . . . Chapter 8



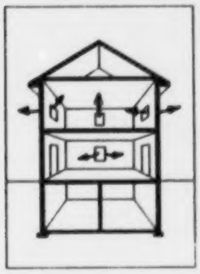
FLOORS OVER UNHEATED SPACES . . . . . . Chapter 9



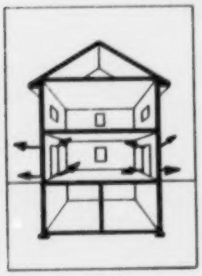
EXTERIOR WALLS . . . . . . Chapter 10



ATTICS AND ROOF SPACES . . . . . . Chapter 11



WINDOWS . . . . . . Chapter 12



DOORS . . . . . . Chapter 13

Within each of these chapters, a brief introduction to the subject is provided, followed by a series of **Worksheets.** Each Worksheet deals with one general kind of sealing requirement, by presenting a series of specific, step-by-step **Procedures.** For instance, Chapter 11 (Attics and Roof Spaces) contains three Worksheets, each one dealing with a particular type of attic. Each of these Worksheets, in turn, contains Procedures related to the specific attic type.

The following 7 chapters are not intended to be read cover-to-cover at one sitting -- they are intended to provide a readily useable reference manual on the practice of air sealing. As a minimum, however, readers should review the introductions to each chapter and to each

Worksheet. This will provide a grounding in the basics of good air-sealing, and will facilitate future access to the specific Procedures.

It must be stressed again that **this section describes how to carry out a wide variety of sealing jobs. The section does not suggest that all or any of these jobs be undertaken in any given house.** For guidance regarding selection of worthwhile sealing jobs, refer to Section II of this Manual.

OVERVIEW OF THE PROCEDURES

The specific Procedures presented in each chapter contain four major elements:

- A list of tools required
- A list of materials required
- Step-by-step procedures for surface preparation
- Step-by-step application procedures.

The step-by-step descriptions focus on the air sealing task, and especially on the measures necessary to achieve a high quality seal. However, there are many finishing steps, beyond those presented in the Procedures. For instance:

- Where construction work has been necessary, surfaces may need to be sanded; nail holes filled; new wood primed and painted; and chipped paint touched-up
- Where the sealing work has caused minor damage to some part of the house, repairs may be required.

These finishing tasks are necessary; by agreement between the householder and the contractor, they can be carried out by either party.

There are other job requirements, above and beyond the Procedures specifically outlined in this Manual, that are not optional. Any contractor is bound by a range of codes: fire, building, electrical, plumbing, health, and gas codes are among those widely encountered. This Manual does not generally specify that applicable codes be followed - but clearly they must be.

Similarly, the Manual does not specify, step-by-step, every health and safety measure that should be applied to each job. These are givens: health and safety is an essential part of any contractor's operation. Accordingly, the next section of this chapter considers this topic.

HEALTH AND SAFETY

In air sealing work, as in most occupations, there are a number of potential risks that confront the employees of any firm. Again, like most other occupations, **there are steps that can, and should, be taken to reduce these risks.** This chapter briefly outlines some of these steps.

Health and safety concerns must not begin and end with the well-being of the installer. The householder, who may be present during installation and who will certainly be present afterwards, has every right to expect the contractor to exercise health-related care and judgement in the execution of any job.

The following pages first discuss safety, then discuss health concerns.

Safety

Air sealing work involves gaining access to virtually every point within a building. It involves the use of a range of types of equipment and tools - and it often requires that they be used in awkward locations. In short, the potential for accidents is significant.

The primary response to air sealing safety concerns is simply good on-the-job accident prevention practice. The basic requirements are simple and familiar:

- Adequate lighting
- Availability of a helper for difficult jobs
- Eye protection
- Proper maintenance of tools
- Etc.

In addition to such basic "good sense", the Canadian General Standards Board "Handbook on Insulating Homes for Energy Conservation" (CGSB 51-GP-42MP) contains a chapter on health and safety that should be referred to by air sealing contractors.

It is worth identifying **some** of the specific safety requirements that have implications for the air sealing contractor:

- Ensure that power is off at lights and outlets when carrying out air sealing work on them. Leave a note on the fuse or circuit breaker advising that the power is off for safety reasons. Otherwise, someone needing a power source may switch a breaker back on, or replace the fuse
- Exercise caution when working in attics, where old wiring may be hidden by insulation. Be especially careful when moving insulation to gain access to areas to be sealed
- High temperatures may occur near flues, vents, and chimneys; be careful when sealing at or near such systems
- Avoid placing hot inspection lights on insulation or in other locations where heat build-up could cause fire
- Many sealants have combustible solvents. Do not smoke while conducting air sealing work, particularly in confined spaces. Keep combustible products away from heat and open flames
- Take extra care when working in attics, due to awkward conditions and associated risk of accident.

Health

Apart from the question of safety, there are potential health problems associated with air sealing work. These problems can be divided into two general categories: installation-related and ongoing.

The installation-related problems are those that occur during or immediately after the air sealing job. These are of concern to both the installer and the householder. The on-going problems are those that can last for weeks, months, or years after the sealing job. They are of obvious direct importance to the householder - but consequently must be of concern to the sealing contractor as well.

For the householder, the most signficant ongoing health problem is probably the potential decline in air quality that can arise from excessively reduced rates of indoor air change. This potential problem, along with appropriate remedial measures, is discussed in Chapter 3 (and, indirectly, in Chapter 4) of this Manual.

A second ongoing health concern is also associated with air sealing: the potential effects of fumes from sealing products. Some sealants, for instance, take months to cure; during this time they may be slowly releasing fumes to the house.

In the category of installation-related problems, the most obvious concern relates, again, to the effects of sealant fumes, solvent vapours, and other sealing chemicals. At the time of installation, levels of some of these gases may become quite significant in the house and, especially, in the work area.

The entire question of the potential health effects of air sealing chemicals, whether at the time of installation or in the longer term, is an area of considerable uncertainty. Some facts are clear, however. It is certain that the use of solvents (mineral spirits, methyl ethyl ketone, xylol, etc.) in enclosed spaces can bring about headaches, dizziness, and nausea. It is equally certain that some sealants should not be used inside because of the fumes they give off (sometimes over an extended period of time). In short, it is certain that the potential health effects of sealants and other air-sealing chemicals should not be ignored, and that precautions should be taken in their use:

- For any sealant or chemical used in air sealing, the manufacturer's instructions should be carefully adhered to. In particular, no sealant marked for exterior use only should be used indoors. Any special handling precautions should be adhered to.
- Sealant selection should include consideration of product toxicity, as outlined in Chapter 7 of this Manual. (See also Appendix 1.)
- Work areas should always be well-ventilated. When working in confined spaces, workers should also have frequent breaks in open or outdoor areas.
- Workers should attempt to minimize the rate at which fumes are generated. For instance, solvent bottles should be capped between uses. Sealant should be applied as generously as necessary for the job - but not moreso.
- Contractors should encourage householders to maintain high rates of indoor ventilation for a few days after the sealing job. The simplest way to provide this ventilation is by opening windows. In winter, there are limits to how much ventilation can be provided while still maintaining comfort levels; however, in winter the extra ventilation may be especially important (since the house would otherwise be completely closed up).

Other installation-related health concerns arise in the course of various sealing activities. Working in the attic, for instance, can result in skin irritation due to contact with insulation materials.

Breathing attic dust, complete with insulation fibres, can potentially lead to respiratory problems. These problesm are relatively easily addreseed by wearing protective clothing (including gloves) and a breathing mask to cover the mouth and nose.

Chapter 7: Materials and their Application

INTRODUCTION

In conducting the sealing work described in this Manual, the sealing contractor will be required to use three different categories of products:

- Sealants
- Weatherstripping
- Miscellaneous materials such as tape and gaskets.

A wide range of products is available in each of these categories. Each product has its advantages, disadvantages, limitations, and range of application. A knowledge of these factors is fundamental to good sealing work, and requires a high degree of skill and experience on the part of the contractor.

This chapter shows the contractor how to select and use the right materials. The treatment cannot be comprehensive, because there are far too many products to be listed in a Manual of this size. However, there are a number of general rules and precautions that the contractor must know, and that will enable him/her to conduct sealing work to the standards required in this Manual. This chapter concentrates on these general aspects, **first for sealants, then for weatherstripping, and finally for the miscellaneous products.**

For definitions of specialized terminology, refer to the glossary at the end of this Manual.

SEALANTS

Introduction

In general, the term "sealant" applies to products that are high in performance, generally moderate-to-high in cost, and have moderate-to-high elasticity. "Caulks" are low in performance, generally have low costs, and have little-to-no elasticity. For convenience, in this Manual the term "sealant" is used to cover both types of material.

Sealing is a **highly specialized skill** with three components:

- Selection of the correct sealant for the job
- Correct preparation of the surface to be sealed
- Correct application of the sealant.

Many people are unaware of these factors; they usually select the first cheap sealant that comes to hand, then apply it incorrectly to cracks and gaps, without paying any attention to the preparation of the surfaces. Such sealing jobs might be effective at first, but more often than not they will fail very quickly and will be a waste of time and money. Such an approach is **not acceptable** for the type of sealing required in this Manual.

There are three basic rules to good sealant technique:

1. No two sealants are alike. Each sealing application has its own special requirements which can be met by a fairly limited range of sealants. It might be more convenient to use whatever sealant is in the caulking gun at the time, but this is bad practice.

2. Surface preparation is not one of those "optional extras", that can be ignored or included according to circumstances. In many cases, surface preparation makes all the difference between a good seal and a useless one.

3. There is a correct way and an incorrect way to apply a sealant. Even if the correct sealant is used and the surfaces are properly prepared, it is possible to apply the sealant in such a way that it will fail within a short period.

The objective of this Manual is to promote sealing work that will remain effective for at least ten years. To achieve this, sealing contractors must acquire a range of specialized skills, and must clearly understand the properties and uses of the available types of sealant.

It must be emphasized that, up to the present time, sealants have been used mainly in exterior applications or in new construction. There is a great amount of information on these applications - from sealant manufacturers, testing agencies, building research agencies, etc.

However, it is only in the last few years that sealants have been used extensively for interior applications in existing houses - which is the type of sealing work that is covered in this manual. There has been scarcely any evaluation or testing of sealants in this type of application, and a number of uncertainties now exist. **Therefore, at the present time, it is impossible to give contractors firm guidance on some aspects of interior sealant applications.**

Sealants: Background Information

Sealants normally take the form of thick, non-pourable materials which consist mainly of:

- a "binder" or "base" material
- a "filler" or "extender" material, and
- a solvent.

The properties of sealants can, naturally, be altered significantly by changes in the type and amount of these ingredients used in the formulation. In addition, a range of other additives are used to produce a wide array of specialized sealant characteristics.

The resulting spectrum of available sealants is very wide. To assist contractors in the evaluation of the various options, therefore, **Appendix 1 of this Manual contains a series of 13 data sheets, each one covering a particular group of sealants.** Taken as a whole, the set of data sheets covers most of the common sealant types and some specialized types.

Factors to consider in sealant selection

For convenience, the wide variety of sealants is sometimes divided into three general categories:

- High performance sealants have good adhesion to a wide range of surfaces and have good elasticity over a wide range of temperatures and over long periods of time. Examples are polysulphide, polyurethane, and silicone sealants.

- Moderate performance sealants have somewhat lower adhesion and elasticity properties. The most important sealants in this category are butyl, acrylic, and polyvinyl acetate sealants. The acrylic sealants are currently showing the greatest growth potential for both interior and exterior applications.

- Low performance sealants have low adhesion and low elasticity. They are generally based on naturally derived polymers or chemicals such as natural oil and bitumens. They are suitable where there is little or no movement of the sealed joint.

This categorization is informative, but, by itself, it is not a sufficient guide to sealant selection. A considerable number of specific characteristics of each available type of sealant must be considered, before the "right" sealant can be selected. These characteristics include the following:

- Extent of expected joint movement: As has been noted, some sealants have high elasticity and can accommodate large movements of the joint gap over a period of several years. Others, such as most "caulks", have hardly any elasticity at all and can tolerate no significant joint movement without forming cracks. Ideally, the sealant should be selected according to the anticipated future movement of the joint.

  However, this creates a problem: there is no reliable way of telling how a joint is likely to behave in the future. The size of the joint or gap is not a reliable indication of future movement. For instance, a large gap may be due to settling of the house during the first few years after construction. In such cases the future movement may be negligible, even though the existing gap is large. On the other hand, a foundation wall crack (for example) may be opening progressively due to water table effects. Thus, a small foundation wall crack may display considerable movement in the long term.

  No firm guidance can be given to contractors on how to assess the potential movement of a joint, though many contractors will probably acquire this skill by experience. **When in doubt, contractors should select high performance sealants** to allow for the possibility of significant joint movement.

- Adhesion: Sealants vary in their ability to adhere to various types of material. Frequently, many sealing jobs involve a joint between different materials (wood to masonry, for instance). In such cases a sealant with good adhesion to both types of material is required.

- Variations in formulation: Several manufacturers may make a sealant of a certain type, and the formulation may vary considerably from one manufactuer's product to another's. The difference often has a considerable effect on the performance of the sealant. For instance, some butyl rubber sealants have a higher solids content than others. They therefore have better non-sag properties and are better suited to some sealing applications (for example, sealing certain foundation cracks). Unfortunately, it is not always clear, from looking at the tube of butyl rubber sealant (to stay with the same example), whether it has a high solids content or not. Contractors may therefore have to consult specifications sheets.

- Sealant emissions: Many sealants contain volatile materials that are emitted during the curing period. As was noted in Chapter 6, some of these emissions are toxic and become hazardous when their concentration in the house air exceeds a certain level. This is one of the greatest areas of uncertainty when sealants are used in indoor applications. The concentration of the harmful material will depend on the amount of sealant used, its exposed surface area, the rate at which the material is emitted, the rate of air movement through the house, and so on. Generally, the greatest risk will be encountered by the contractors during sealant application, particularly if they are working in a confined area with poor air movement. However, there may also be a risk to the house occupants, since many sealants take several weeks to cure.

Some manufacturers label their products as having harmful emissions or as being unsuitable for interior use. **Contractors should not use such products for the sealing work described in this Manual.**

No firm guidance can be given on the emissions aspect of sealant use, except to avoid products that are clearly labelled as being hazardous or unsuitable for interior use. Some home owners may not object to a particular emission, while others may display some reaction. Contractors will have to learn, by experience, which sealants are acceptable and which are not. In the next few years, it is possible that a proper system of guidelines and standards will be put in place.

- Drying times: The drying time is normally expressed in two ways: the tack-free skinning time (dry "to touch") and the total-cure time. The total cure time is the more important, since it determines the period over which volatile materials may be emitted into the house air.

  It is important to note that the curing time varies according to formulation, and may differ considerably (for a particular type of sealant) from one manufacturer's product to another's. Some butyl sealants, for example, have curing times of about 100 days, while others have curing times of about a week.

- Colour matching and paintability: Some sealant types are offered in a wide range of colour types and can be selected to give a reasonably close match to most surfaces to which they are applied. Other sealant types (eg. some silicone sealants) will not accept a coat of paint. This sould be taken into account when the sealant is left exposed.

- Gap size: Sealants become ineffective when applied to gaps below a certain minimum width or above a certain maximum width. The permissible gap width varies considerably according to the sealant.

- Exposure to moisture: Contractors should familiarise themselves with the moisture conditions that limit the effectiveness of sealants. Water based (latex) sealants, for instance, benefit from the presence of moisture during application, but not afterwards.

- Temperature limitations: Installed sealants can normally accommodate high and low temperatures well beyond those likely to be experienced by sealants used in interior air sealing. However, sealants have two other types of temperature limitation: storage temperature and application temperature. Sealants may be impaired if they are stored below the required storage temperature. For instance, some latex sealants become unstable when stored below 0°C. Also, many sealants fail to make an effective seal, or become difficult to "work", if they are applied below a certain specified temperature. **Contractors should familiarise themselves with the temperature limitations on the sealants they use or might use.**

- Priming requirements: Some sealants are ineffective unless applied to surfaces that have been prepared with special primers. Usually, special primer requirements are indicated on the sealant package. The necessary products are usually available along with the sealant.

- Cost: Usually (but not always) cost is related to quality and performance of the sealant. An extra dollar spent on a tube of sealant is sometimes an excellent investment in terms of durability and effectiveness of the seal.

Sealant selection

On the basis of these various factors, and in consideration of the properties of the various available sealants, Chapters 8-14 of this Manual specify suitable sealants for each of the types of sealing job described. However, these recommendations refer to **common** situations - not necessarily to **all** situations. **It is essential, therefore, that contractors understand the sealant selection factors just described, and be familiar with the characteristics of the various available sealants** (see Appendix 1 of this Manual). Only in this way will the contractor be reasonably sure of using the right sealant, in the right way, on each job.

As a further guide to contractors, Table 7.1 on the following page has been prepared. Like the recommendations in the following chapters, **this table must be used with caution**: it does not apply to all the sets of conditions that contractors will encounter. The recommended sealants will be adequate in the majority of cases. But in some applications they will be unnecessarily expensive and in others they may not be effective enough, depending on conditions. The table is only a rough guide; contractors are advised to base their selection on the data sheets in Appendix 1 as far as possible.

Surface preparation

Selection of the proper sealant is essential, but so is proper surface preparation. **Improper surface preparation is likely to result in inadequate sealant performance.**

Before applying sealant, the working surfaces should be clean, free of loose material, and preferably dry - though there are a few sealants which work slightly better when applied to a damp surface. The working surfaces should be prepared with a wire brush or scraper, to remove all dirt, loose material, old paint, old sealant, etc. - as far as is practicable.

TABLE 7.1

A GENERAL GUIDE TO SEALANT SELECTION

(Caution: see remarks on the previous page)

Application	Suitable Sealant Types
Wood to wood	All acrylic sealants, if the gap is less than 9 mm. Silicone sealants for gaps greater than 9 mm.
Wood to masonry	Butyl rubber for gaps up to 12 mm. Polysulphide for gaps up to 19 mm and for damp conditions.
Wood to metal	All acrylics for gaps up to 9 mm. Butyl rubber for gaps up to 12 mm. Silicone sealant for gaps up to 25 mm and for gaps that are expected to display large movement. Urethane foam sealant can be used for gaps above 25 mm but will not be effective if there is large gap movement.
Masonry to masonry	Butyl rubber for gaps up to 12 mm. Polysulphide for gaps ranging from 9 mm to 19 mm. Grouts and special water-stop fillers for gaps above 19 mm. Polysulphide is a good choice where there is significant gap movement.
Polyethylene	Acoustical sealant. Note that this is not an adhesive, and must be supported mechanically with staples or other support.
High temperatures	Silicone sealants are effective at fairly high temperatures, but their temperature limit should not be exceeded. Room Temperature Vulcanised (RTV) silicone sealant is suitable for high temperatures, but requires very specialised application procedures. High temperature stove sealants or muffler cement can also be used.
High humidity	Most silicones are suitable. Water-based vinyl acetate sealant is acceptable, if it has fungus and mildew retardants.

FIGURE 7.1

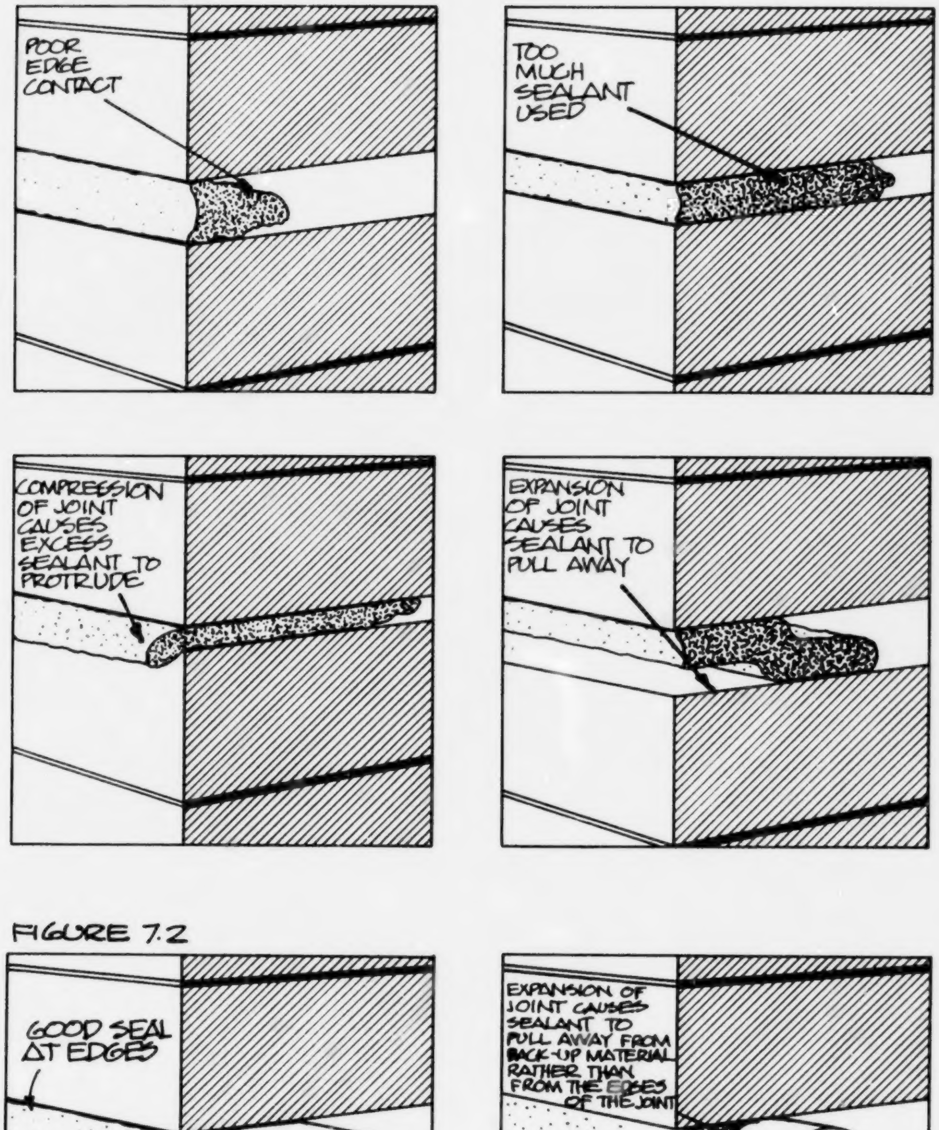
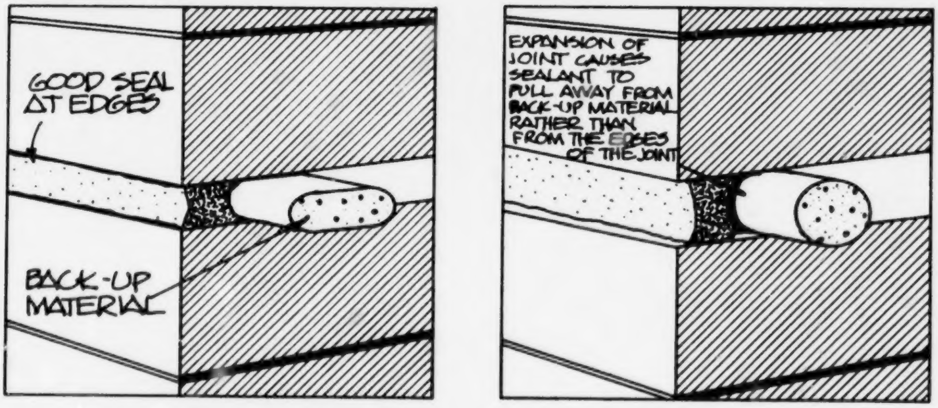

POOR EDGE CONTACT
TOO MUCH SEALANT USED
COMPRESSION OF JOINT CAUSES EXCESS SEALANT TO PROTRUDE
EXPANSION OF JOINT CAUSES SEALANT TO PULL AWAY

FIGURE 7.2


GOOD SEAL AT EDGES
BACK-UP MATERIAL
EXPANSION OF JOINT CAUSES SEALANT TO PULL AWAY FROM BACK-UP MATERIAL RATHER THAN FROM THE EDGES OF THE JOINT

The working surface should then be cleaned using MEK (methyl ethyl ketone) or mineral spirits. The use of methyl ethyl ketone (MEK) is frequently recommended in this document. However, caution is advised in its use on some surfaces. Specifically, **MEK must never be applied to electrical wiring, plastic, or rubber (since it may attack these materials).** In addition, MEK can break down paint. Depending on the quantity used and how vigorously it is applied, the paint finish may be affected (requiring touch up painting after the sealant has cured). Mineral spirits may be used as a substitute provided that sufficient time is allowed for any excess to evaporate prior to the application of the sealant. The quality of the mineral spirits used should be such that the prepared surface is left free of oily deposits.

All cleaning should be done with a clean white rag to avoid the risk of discolouration around the sealed joint. Some sealants have specific cleaning needs: **contractors should always follow the sealant manufacturer's recommendations on surface cleaning.**

In some cases, further preparation of the working surfaces may be required. Specifically, some sealants are ineffective when applied to certain surfaces, and it is therefore essential to prime the surface first. **Contractors should always follow the manufacturer's recommendations on surface priming.**

Back-up materials

When sealing large gaps, it is good practice to use some kind of back-up material. This serves two purposes: it reduces the amount of sealant required to seal the gap, and it makes it easier to work the sealant into good contact with the sides of the gap. Figure 7.1 shows some of the problems that can occur if proper back-up materials are not applied. Figure 7.2 illustrates some of the characteristics of a joint sealed with back-up material.

There are several types of back-up product manufactured specifically for this type of application. They may take the form of rods of closed-cell material, known as backer rods, or they may consist of hollow tubular material. The material should be non-moisture absorbent and should remain flexible at low temperatures. Typical materials used in back-up products are neoprene, butyl rubber, and EDPM. **When selecting back-up materials, it is important to bear in mind that the back-up must not adhere to the sealant.** Under normal crack movement, the back-up will deform. If the back-up is bonded to the sealant, this deformation will be transferred to the sealant and may cause it to crack.

Special care is needed when installing back-up material. If the back-up is punctured in any way during installation, then any long-term opening or closing of the crack could cause air to be forced out of the back-up, or sucked into it. This could cause the sealant to bubble, or it could exert pressure on the sealant - both mechanisms that might ultimately damage the seal. This applies both to closed-cell and tubular back-up types. Consequently, **when installing back-up materials, contractors should take special care not to puncture these materials. A blunt insertion tool is recommended.**

To achieve adequate compression of the back-up inside the crack, **it is standard practice to use a back-up whose diameter is about 25% greater than the width of the crack.** Contractors should follow this practice. In addition, there are general rules for the depth of insertion of a back-up in a crack:

- If crack width is less than 6mm, then back-up is not required
- If crack width is 6mm to 12mm, then the back-up should be installed to allow sealant depth of 6mm
- If crack width is 12mm to 25mm, then back-up should be installed to allow a sealant depth that is half of the crack width
- If crack width is over 25mm, then the back-up should be installed to allow sealant depth of 12mm.

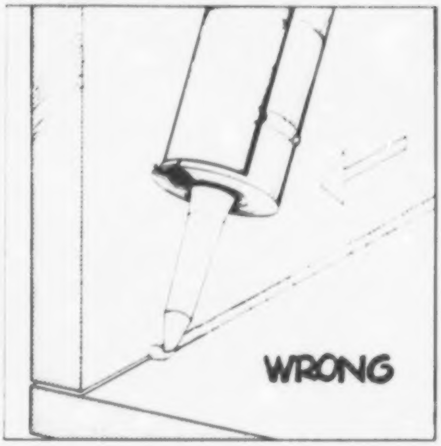
In general, if these rules are not followed, there is a risk that the sealant will fail in some way. Note, however, that some sealants, particularly those of the "caulk" type, can tolerate a greater range of depths.

Application of Sealants

Before applying any sealant, **contractors should be familiar with the manufacturer's recommendations regarding ventilation** during and immediately after application. Contractors should also be aware of any special **requirements regarding skin and eye contact with the sealant.**

Sealant materials are most commonly packaged in tubes, and are dispensed with a caulking gun. Caulking guns come in two sizes, to match the two standard sizes of sealant tubes: 310ml and 810ml. The smaller size is best suited to the large range of sealants that are available in many retail outlets. The larger size is best suited to the more specialised range of sealants that is available through builder's suppliers. Contractors are advised to make use of both sizes, according to circumstances. (More elaborate commercial caulking units are also available. It is not necessary to use such equipment for the standard air sealing work described in this Manual. Note, however, that use of some of the specialised sealants does require non-conventional application equipment.)

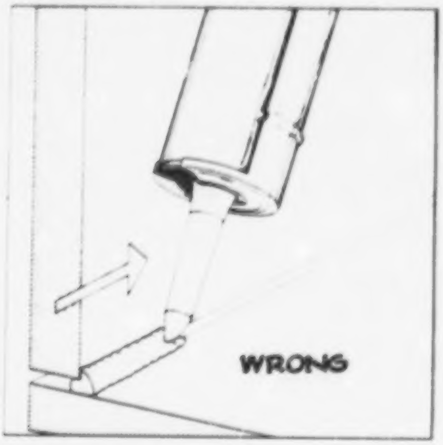
FIGURE 7.3



The nozzles on the sealant tubes are tapered and can be trimmed to give a wide range of opening sizes. The opening size should be selected according to the required width of the sealant bead. **It is recommended that the nozzle be trimmed squarely, rather than at an angle.**

When the sealant is applied to a crack, the effectiveness of the seal depends on the consistency of the sealant, the speed of application, and the angle of the caulking gun. If the gun is angled to point in the direction of travel (Figure 7.3), the edge of the nozzle will wipe the sealant bead. It will tend to force the sealant into the crack, and the wiping action gives a neater and more uniform bead. However, the bead

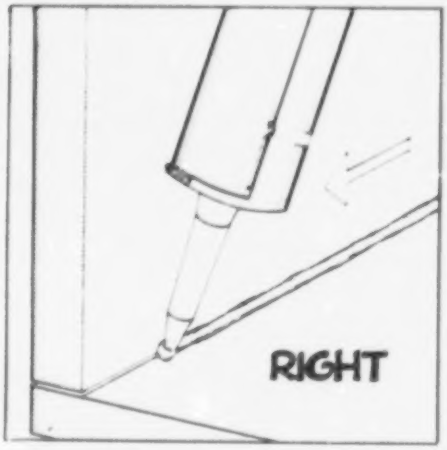
FIGURE 7.4



is left with a concave surface, and when curing, the sealant may shrink to the point where a crack develops along the bead. This technique therefore gives a seal that may not be effective in the long term.

If the gun is angled away from the direction of travel (Figure 7.4), this tends to give a convex and irregular bead surface. Unfortunately, this technique is ineffective in forcing the bead into the crack. Large air gaps may be left under the bead, and these will open up as air leakage gaps when the sealant shrinks.

FIGURE 7.5



The best technique, therefore, is to hold the gun approximately perpendicular to the line of travel (Figure 7.5). This has three advantages: it tends to force the sealant into the crack, it allows the contractor to see how well the sealant is running into the crack, and it leaves a slightly convex surface on the bead to compensate for shrinkage.

In practice, the speed of gun movement and the trigger pressure should be regulated so that the sealant runs slightly ahead of the gun and rises slightly behind the gun. By inspecting the sealant bead ahead of the gun, it is possible to see how well the crack is being filled. It requires little practice to achieve a uniform and effective bead with this technique, though some variations in the technique may be necessary when dealing with sealants of different consistencies.

Tooling the bead

In many instances the sealant bead will be concealed by replaced trim, baseboards, etc. In such cases it is not necessary to tool the bead to give a neat and uniform appearance. However, when the bead is exposed, it may sometimes be advisable to tool the bead to improve its appearance. This should be done only when the sealant is no longer tacky to touch. Metal or plastic tools are usually ineffective, since they may adhere to the bead and make it look worse rather than better. Finger tooling, by running a wetted finger lightly along the surface of the bead, is often the most effective technique. (Note however, that with some sealants skin contact should be avoided. Refer to Appendix 1 and the manufacturer's instructions.)

Strong pressure must not be applied when tooling a bead. The objective is to give a smooth, uniform surface - not to compress the bead into the crack. If the bead is compressed excessively, this may destroy the long-term effectiveness of the sealant. It may also leave a noticeable depression in the bead after curing and shrinkage.

WEATHERSTRIPPING

Introduction

Weatherstripping is used to control air leakage at joints where two materials meet and move relative to each other. Doors, windows, attic hatches, exterior vents, etc., can all be weatherstripped to reduce air leakage.

Often, weatherstripping can be quickly and easily performed. In other cases - especially with some types of windows - considerably more effort will be required.

Regardless of the complexity of the job, proper weatherstripping (like proper sealing) demands that attention be paid to at least three factors:

- Selection of the correct weatherstripping product for the particular job
- Proper preparation of the surface to which the selected product will be attached
- Proper installation of the product.

If any one of these aspects is ignored, the long term effectiveness of any weatherstripping job will be jeopardized. Accordingly, the following pages consider, in turn each of the above three aspects of good weatherstripping practice.

Factors to consider in weatherstrip selection

Many types of weatherstripping are available across the country. Selection of the proper product involves consideration of two key factors:

- The material used to make the weatherstrip (rubber, plastic, metal, etc.)
- The "style" or type of weatherstripping (tubular, spring loaded, "V"-strip, etc.).

The two factors are not entirely independent, since some types of weatherstripping are available in only one material. (For instance, one useful weatherstripping material is the magnetic strip, which is used only in magnetic-type weatherstripping.) Nevertheless, since **product selection must consider both weatherstripping material and weatherstripping type,** it is important to understand the considerations associated with each.

Weatherstripping materials

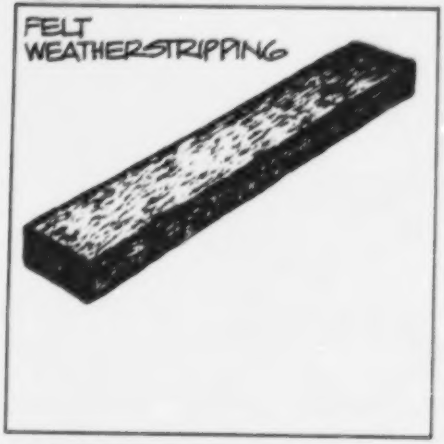
The key concern with respect to weatherstripping materials focusses on the "active" material - the part of the product that actually makes the sealing contact when a door or window is closed. These "active" materials must have certain properties to ensure proper performance over the long term.

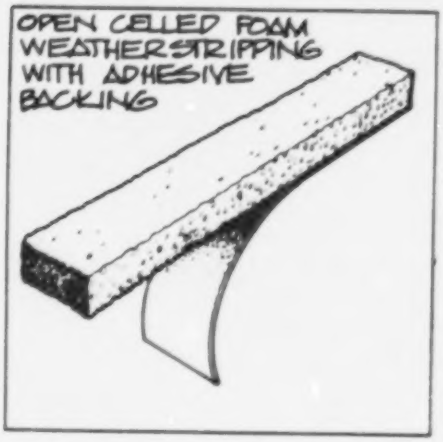
First, a minimum life expectancy of 10 years is absolutely necessary for the material. Because weatherstripping is exposed to environmental conditions, the material should be resistant to oxidation, ultra-violet light, ozone, etc. over prolonged periods.

Second, since weatherstripping materials are always under some type of compression or deflection, the weatherstripping material must have adequate resistance to becoming permanently set in a compressed shape. This is referred to as "compression set resistance". A material with good compression set resistance will have good "memory": it will be able to bounce back to its original shape. This ensures that the weatherstrip will continue to provide a good seal over an extended period of time (if properly installed).

Third, weatherstripping in Canada is mostly needed in the winter. Thus, weatherstripping material must function well in cold and variable weather. Ideally, it should not crack, harden, or shrink unduly.

FIGURE 7.6





On the basis of these (and other) considerations, two low cost weatherstripping materials are clearly inappropriate for any quality air-sealing work: felt and open celled foam. Neither material is durable or particularly effective. (Both of these products are normally available in strip form, as shown in Figure 7.6.)

There are, of course, a number of higher quality weatherstripping materials. In order to clearly outline their relative characteristics, Appendix 2 contains data sheets on the five most important groups of "active" weatherstripping materials:

- Rubber (EPDM or neoprene)
- Plastics (PVC, TPR, or polypropylene)
- Metal (steel, bronze or brass)
- Pile
- Magnetic strips.

In reviewing the characteristics of these materials, it must be remembered that material quality is but one factor in the selection of weatherstripping. The type or style of product is also a key concern. (Indeed, it is often the deciding factor since, as noted above, some types of seals are available in only one or two materials.)

Weatherstripping type

There are a great many weatherstripping types. Tables 7.2 and 7.3 on the following pages provide an overview of some of the major alternatives, including those suitable for general application (Table 7.2) and those intended for specialized application to the bottom of doors (Table 7.3).

TABLE 7.2

A REVIEW OF WEATHERSTRIPPING TYPES: GENERAL USE

Weatherstripping Type	**Comments**
Closed cell foam on attachment strip Cost : medium See Figure 7.7	. A good sealing weatherstrip used on doors and windows. Installation is performed by nailing the attachment strip to the jamb of the door or window . If installed so as to provide an overly tight seal, operation of the door or window may be hindered . On the other hand, installation that provides inadequate compression of the foam will allow air passages and drafts . May not be durable when used on sliding windows and doors since abrasion can lead to deterioration of the foam.
Closed cell rubber with adhesive backing Cost : low See Figure 7.8	. A relatively effective weatherstrip that provides a good seal when under compression (for instance, doors, hinged windows, and clamped attic hatches) . Cannot accomodate large variations in gap width . The closed cells prevent air infiltration or exfiltration . Installation is easy, but counts on adhesive properly adhering to surfaces.
Tubular Cost : low to medium See Figure 7.9	. A weatherstrip which, if properly installed, can provide an effective seal . A good seal does not demand that a significant amount of pressure be extended on the door or window. (If considerable pressure were required, operation of the door/window would be impeded.)

FIGURE 7.7

CLOSED CELL WEATHERSTRIPPING ON ATTACHMENT STRIP

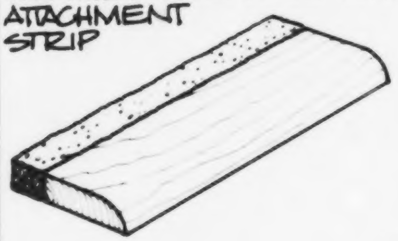


FIGURE 7.8

CLOSED CELL RUBBER WEATHERSTRIPPING

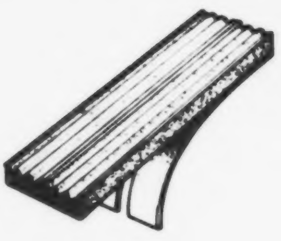


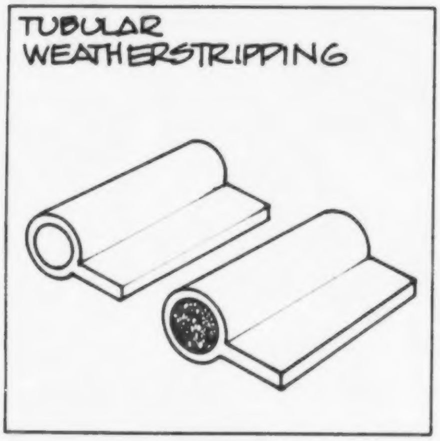
TABLE 7.2

A REVIEW OF WEATHERSTRIPPING TYPES: GENERAL USE

(continued)

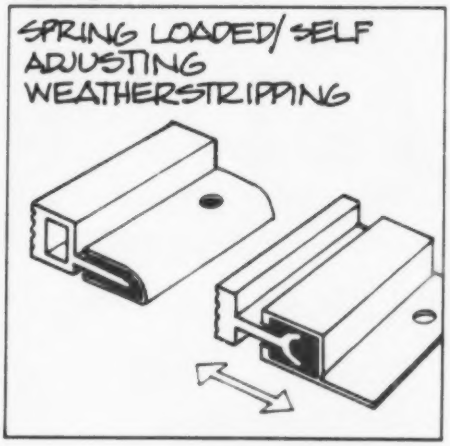
Weatherstripping Type	Comments
Tubular (continued)	. Installation is usually performed with nails or staples through the material to the door or window stop . Tubular strips on attachment strips allow for easy installation with screws . With or without attachment strips, installation is noticeable . Available in rubber and plastic materials - see Appendix 2. Plastic materials are more susceptible to deformation in colder weather and generally have less "compression set resistance".
Spring loaded/ self adjusting **Cost : high** **See Figure 7.10**	. An effective sealing weatherstrip for doors and hinged windows . Utilizes a spring mechanism that allows the weatherstip to adapt to unequal distances from the weatherstrip to the door or window . Installation is by screws through the attachment strip to the door/window stop or jamb . Can be adjusted with ease to meet changing crack width . With the use of a durable "active" material (i.e., the material that actually makes the sealing contact), this weatherstrip will have a long life - see Appendix 2.

FIGURE 7.9



TUBULAR WEATHERSTRIPPING

FIGURE 7.10



SPRING LOADED/SELF ADJUSTING WEATHERSTRIPPING

TABLE 7.2

A REVIEW OF WEATHERSTRIPPING TYPES: GENERAL USE

(continued)

FIGURE 7.11

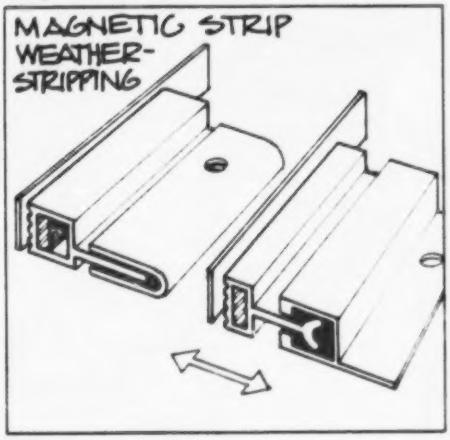
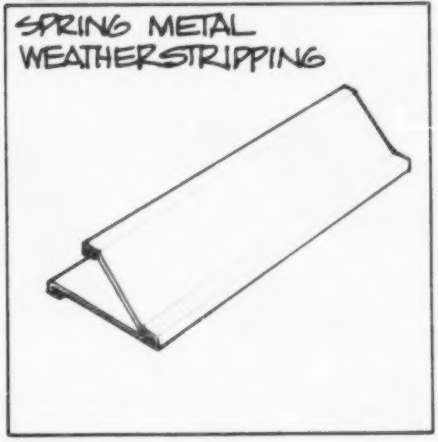


FIGURE 7.12



Weatherstripping Type	Comments
Magnetic Cost : high See Figure 7.11	. A weatherstrip that can provide an effective seal for doors and windows . Seal is provided by the magnetic attraction between a magnetic strip mounted on the door/window frame and a metal strip mounted on the door/window. (The metal strip is unnecessary in the case of steel doors.) . Vinyl attachment allows for easy installation with screws . Installation of the metal strip demands a second step in installation procedure . See Appendix 2 for additional comments.
Spring metal cost : medium See Figure 7.12	. An effective weatherstrip for doors and windows . Metal strips under light compression can provide a good airtight seal over extended periods of time . Installation is often difficult, since the material must be tacked to the jamb . Improper wear can result in the ripping of the metal stripping and, in some cases, the metal may permanently deform to the shape it is forced to take when the door/window is closed.

TABLE 7.2

A REVIEW OF WEATHERSTRIPPING TYPES: GENERAL USE

(continued)

Weatherstripping Type	Comments
Plastic "V" - type Cost : low to medium See Figure 7.13	. An effective and versatile weatherstrip for use throughout the house . Strips may be equipped with adhesiv backing for easy installation . Protection against failure of the adhesive backing can be supplied by stapling through the back edge of the strip . The material is available in a variety of shapes, widths and thicknesses, depending on the size of the gap to be sealed.
Polyester or polypropylene pile, with or without fin seal Cost : medium See Figure 7.14	. A weatherstrip providing a reasonably effective seal . Used primarily as a replacement seal for sliding windows, doors, and similar products . Available on plastic and metal attachment strips and in "T" slot configurations . See Appendix 2 for additional comments.

FIGURE 7.13

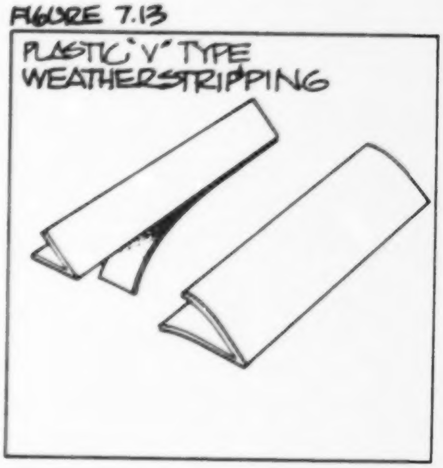


FIGURE 7.14

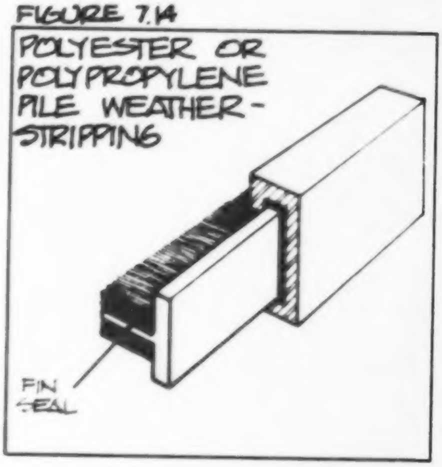

POLYESTER OR POLYPROPYLENE PILE WEATHER-STRIPPING
FIN SEAL

TABLE 7.3

A REVIEW OF MAJOR WEATHERSTRIPPING TYPES: BOTTOM OF DOORS

Weatherstripping Type	**Comments**
Sweeps Cost : medium to high See Figure 7.15	. An effective type of weatherstrip for the bottom of doors . The long term effectiveness is dependent upon the "active" material used in the sweep. The best material is rubber (EPDM or neoprene), followed by plastics (PVC, Vinyl) and then pile. See Appendix 2 . Installed by nailing or screwing through attachment strip to door. Provides a relatively easy installation where the floor is level, but can impede operation if the door or floor is out of square . Automatic sweeps with self-adjusting sweep can alleviate concerns about uneven floors . Good durability when properly installed . Some products have sweeps that are replaceable without replacing attachment strip.
Partial thresholds Cost : medium to high See Figure 7.16	. An easily installed weatherstrip . Certain materials can be easily damaged by traffic, trapped stones, ice, etc. Most desirable gasket materials are rubber (EPDM or neoprene) followed by plastics (PVC, vinyl). See Appendix 2 . Does not require bottom clearance on door. . Some products have gaskets that can be replaced without having to replace the full weatherstrip.

FIGURE 7.15

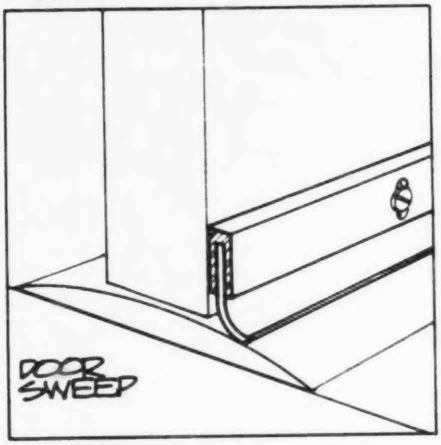


FIGURE 7.16

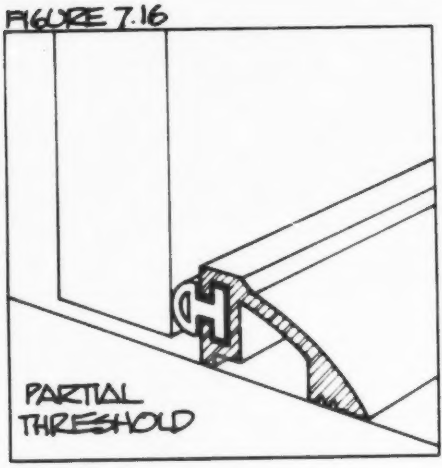


TABLE 7.3

A REVIEW OF MAJOR WEATHERSTRIPPING TYPES: BOTTOM OF DOORS

(continued)

Weatherstripping Type	Comments
Full width threshold Cost : high See Figure 7.17	. An effective weatherstrip for doors with at least 15mm clearance below the door . Full width thresholds usually have an adjustable insert for broader gaps (up to 30mm) . Difficult initial installation and relatively easy replacement of worn gaskets . Gasket material should be chosen for best performance and long life. The most desirable materials are the same as for a partial threshold.
Door bottoms Cost : high See Figure 7.18	. An effective weatherstrip for doors with clearance of between 8mm to 13mm below the door . Gasketing provided by rubber, plastics, spring metal, or pile. See Appendix 2 . Can be damaged by trapped gravel, etc . Replacement gaskets available for many products.

FIGURE 7.17

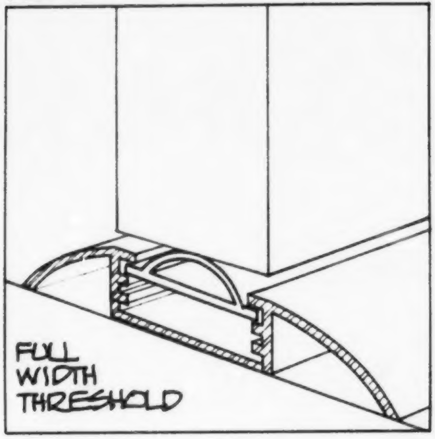
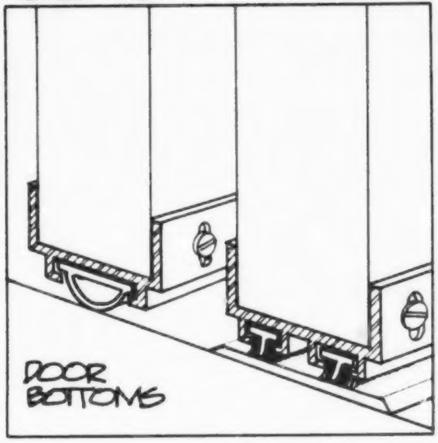


FIGURE 7.18



Selection of weatherstripping

The "right" weatherstripping product for any job will provide a long lasting, efficient seal with a minimum life expectancy of ten years; will have an acceptable appearance when installed and after a period of service; and will be relatively easy to work with. Selection of a product that meets these criteria requires consideration of the factors just discussed: material characteristics and the type (or style) of weatherstripping required.

On the basis of these considerations, this Manual recommends suitable weatherstripping products for most of the weatherstripping jobs described (Chapters 11 and 12). Though these recommendations should generally be followed, they are not absolute. Contractors will encounter unusual circumstances that will require them to make a careful selection of alternative weatherstripping products. Such selection should be guided by the discussion in this section.

Chapter 13 (Doors) does not make specific product recommendations, since the variety of door types likely to be encountered is large, as is the array of specialized products. Instead, Chapter 13 identifies key, door-specific considerations. Review of these factors, in conjunction with those outlined in this chapter, should allow the contractor to make wise product selections.

Surface preparation

The right weatherstripping product, applied on an inadequately prepared surface, is not likely to provide an effective, long-lasting seal. A clean surface for mounting is important for adhesive backed types of weatherstripping; an even surface is important for all types.

Proper surface preparation may involve several steps - but in most cases it will be relatively quick and easy. Materials which are to be weatherstripped should be thoroughly cleaned to remove dirt, oil, grease, flaking paint, wood splinters, etc. Uneven surface should be levelled with a hand plane or sanded. Major gaps or cracks should be filled with a latex wood filler. Before weatherstripping windows and doors, any major structural flaws (warped frames, missing stops, etc.) should be repaired or trued as required.

In addition, since some weatherstripping applications require the use of sealant, any special surface preparation required by the sealant manufacturer should be carried out. Finally, for adhesive backed weatherstrips, the surfaces should be completely dry before application.

Application of weatherstripping

Most weatherstripping can be easily installed with the use of standard tools (i.e., hammer, screwdriver, staple gun, etc.). Some materials also require other tools for cutting: metal thresholds, door bottoms, and attachment strips are cut with a hacksaw, for instance.

Weatherstripping can be installed throughout the year, but temperature will affect the installation of certain materials. For installation at sub-zero temperatures, vinyl materials should be maintained at room temperature prior to installation (since cracking can occur when the material freezes).

As a general rule, adhesive materials used in weatherstripping products are not affected by extremes in temperature. However, while most adhesive backed materials are meant to be installed without additional mechanical fastening, it is advisable to reinforce the seal with staples (regardless of application temperature).

Weatherstripping should be installed in continuous pieces, with gaps or splices being limited to the corners of the window or door. Materials should butt tightly at the corners to reduce any air leakage. Application of a sealant at corners is recommended. Also, whenever there is any risk of air leakage underneath the weatherstripping (i.e., through the gap between the strip and the surface to which it is applied), application of a thin bead of sealant under or against the weatherstripping is recommended. This can be particularly beneficial in the case of rigid weatherstripping and in the case of surfaces that remain slightly uneven, in spite of reasonable preparation.

Details regarding position of weatherstripping materials, orientation, etc. tend to be determined by the characteristics of each particular type of job. Accordingly, such topics are covered in the specific procedures outlined elsewhere in this Manual. Contractors who follow these procedures and the general guidelines presented above can routinely expect to achieve good quality, durable weatherstripping seals.

MISCELLANEOUS MATERIALS AND PRODUCTS

This section gives a brief summary of a range of miscellaneous materials and products which the contractor will be required to use in sealing work:

Duct Tape

In air sealing work, duct tape is used primarily for sealing joints in those ducts that are routed outside the heated interior of the house (such as a heating duct that is run through an attic). The tape can also be used on ducts within heated basements, to prevent excessive heat spilling into the area. Because duct tape generally has poor long term adhesion, it is advisable to clean the surface to which the tape will be applied, and to use at least two laps of tape.

Duct tape is sometimes used to seal wide constructional gaps. This is not always advisable, however, since duct tape has very poor adhesion to masonry, drywall, and natural wood surfaces. Adhesion can be improved by painting the surfaces first. Duct tape is also used for some other specific air-sealing tasks, described elsewhere in this Manual.

Electrical outlet gaskets

Electrical outlet gaskets are designed for fitting behind the cover plates of electrical switches and outlets. They reduce air leakage around the edges of the cover plate, and are therefore useful when the cover plate makes poor contact with the surrounding wall. It is better to use such gaskets than to apply sealant around the cover plates; sealant use may result in an unsightly bead around the cover plate, and may also make it difficult to remove the cover plate for repair of the electrical installation.

Gaskets are made by various manufacturers in various materials: open celled foams and closed cell rubber. The closed cell gaskets give a better seal. Only a few gasket products have been approved by CSA, and contractors should restrict themselves to CSA approved designs.

Safety plugs

Plastic child safety plugs are available at most hardware outlets. These are inserted in electrical outlets to reduce the risk of electrical accidents involving children. However, they also reduce air leakage through the electrical sockets, and so are recommended in this Manual as a sealing technique.

Window and door hardware

Air leakage through doors and windows is often the result of poor seals. However, in some cases, it may instead be due to the fact that the windows and doors, when closed, are not being pulled tightly against the existing, perfectly adequate seals. In some cases, this can be remedied by adjusting the existing hardware, but in other cases it may be advisable to install a more positive clamping mechanism. Several simple and effective clamping devices are available, usually in the form of sash locks. Some anti-burglar attachments for windows are also effective in tightening the window seals.

The same general principle applies to attic hatches. In this Manual, sash locks are recommended as an air tightening measure on poorly sealed hatches.

Grouts

Grouts are the materials used for sealing cracks in concrete and masonry (among other things). A wide range of materials is available for this type of sealing.

The simplest type of grout is standard mortar, or water-stop mortar mixes with a resin base. These have good filling properties and will give a good, durable seal if the crack experiences no further movement. They maintain a good seal when the crack is under compression, but will easily open up when the crack is under tension.

Where concrete or masonry cracks show a progressive widening, it is preferable to use special grout formulations that have high elasticity. These can then stretch with the crack, without losing their seal. Such formulations are available in a range of dry mixes, or as pre-mixed materials in standard sealant tubes. (Note also that some sealants, such as butyl rubber or polysulphide, can also be used effectively as grouts.)

Chapter 8: Foundations

INTRODUCTION

The majority of Canadian houses have heated full basements with one of three main types of construction:

- Cast-in-place concrete
- Unit masonry (eg. concrete block, cinder block, brick, etc.)
- Stone (eg. dressed stone, rubble, etc.).

These types have many features and problems in common, and account for about 80% of house foundations in Canada. This chapter is concerned with the air leakage problems of such foundations.

Other foundations types will be encountered less frequently by the sealing contractor. These include:

- Pressure treated wood foundations
- Earth basements (or dugout basements)
- Slabs-on-grade
- Crawl spaces

The air leakage problems of such foundations are not specially covered by this edition of this Manual. Note, however, that some of the techniques presented in the following pages will be useful in the case of the "minority" foundation types. In the case of unheated crawl spaces, refer to Chapter 9.

Concentrating on the three main basement types, the major sources of air leakage **through the foundation** are as follows:

- Cracks in foundation walls and floors
- The joint between the foundation wall and the wood frame
- Windows
- Exterior doors
- Service entrances (gas, electricity, etc.)
- Old openings, such as coal chutes
- Vents and ducts.

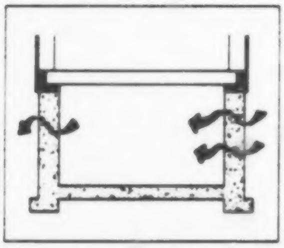
This chapter describes the various sealing techniques for each of these various types of foundation air leakage.

Note: In addition to air leakage through the foundation, many houses will have air leakage from the basement into the attic via such paths as furnace chimney enclosures and plumbing walls. These sorts of air leakage paths are considered in Chapter 11: Attics and Roof Spaces.

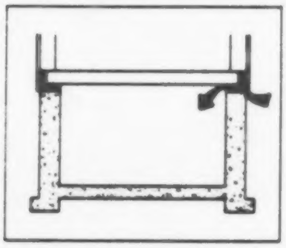
For definitions of specialized terminology, refer to the glossary at the end of this Manual.

GUIDE TO THE WORKSHEETS

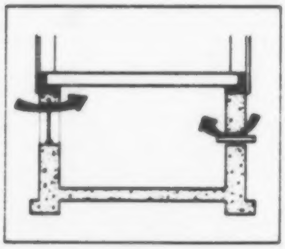
The following pages contain three Worksheets, each concerned with a different aspect of foundation sealing:



Procedures for sealing **FOUNDATION CRACKS** . . . . . . Worksheet 1



Procedures for sealing the **FOUNDATION/MAIN FLOOR JOINT** . . . . . . Worksheet 2



Procedures for sealing **PENETRATIONS THROUGH THE FOUNDATION** . . . . . . Worksheet 3

For each specific procedure described in each Worksheet, preparation and application requirements are described step-by-step. In addition, the necessary tools and materials are identified in each case.

For most foundation sealing jobs, it will be necessary to refer to all three Worksheets (unless there are no cracks in the foundation walls and floor). In the special case of basements developed as living areas (where the foundation wall is covered with a stud frame wall), Worksheet 2 should be referred to, along with the general wall sealing measures presented in Chapter 10.

Worksheet 1:
Procedures for sealing foundation cracks

INTRODUCTION:

This Worksheet is concerned with the sealing of cracks in the foundation wall and floor. These cracks are often a major source of air leakage. There is a tendency to believe that air leakage through basement cracks must be small, since the floor and most of the foundation are usually surrounded by soil. But this is not correct; soil offers very little resistance to air movement. Contractors can check this by observing how much air moves through basement wall cracks (below grade) during airtightness tests.

As was pointed out in Chapter 2, the air leakage in the basement area is mostly inwards: ie. infiltration. This has two undesirable effects: first, it contributes to the air change heat losses of the house; second, it introduces airborne pollutants into the house from the surrounding soil. The most important of these pollutants (as far as is known) is radon gas. This gas is generated from trace radioactive materials in the soil, and varies in importance from region to region according to soil type. In some locations, where the soil radon content is high, sealing techniques should be applied in the basement area as a priority, in order to reduce radon build-up in the house air.

Background on foundation cracking

The majority of structural problems in houses (perhaps as high as 70%) occur in basement walls and floors. A significant proportion of these problems involve wall and/or floor cracking.

Foundation wall cracks may have several causes, or combinations of causes, including:

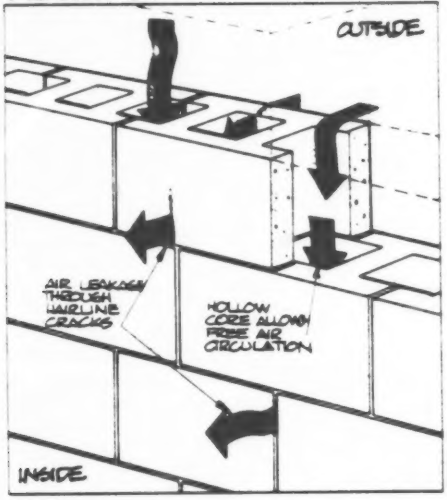
- Sub-standard construction work
- Soil movement due to water effects (as in expansive clay soils)
- Soil movement due to temperature-related effects (as in the formation of ice within the soil)
- High water tables
- Poor arrangements for the runoff of rain water
- Defective weeping tile and drainage systems at the footing level
- Inadequate preparation of the foundation wall exterior to guard against water infiltration.

Basement floor defects have a similar range of causes, though water table and drainage effects, together with the quality of the basement floor installation, are the most important.

Foundation cracks range in size, from microscopic up to long cracks with widths of about 25mm. Using the term "crack" very loosely, the smallest "cracks" are the pores in the concrete, mortar, etc. Water can seep through these pores by the process known as capillary action or "wicking". Where water can infiltrate, so can air.

Next in size are hairline cracks, with widths of typically 1mm and lengths that vary according to the type of construction. In poured concrete foundation walls and floors, these cracks may arise from structural movement or improper curing procedures at the time of installation. In unit masonry walls, hairline cracks commonly occur along the mortar joints, where the cracking is indicative of poor mortar or of foundation settling. In such unit masonry walls, even small cracks may act as large sources of air leakage, since they may be

FIGURE 8.1


OUTSIDE
AIR LEAKAGE THROUGH HAIRLINE CRACKS
HOLLOW CORE ALLOWS FREE AIR CIRCULATION
INSIDE

linked to large cavities within the wall (such as those that are found in some concrete blocks or cinder blocks, as shown in Figure 8.1).

Larger visible cracks have various lengths and widths, and usually indicate major foundation or floor movement (caused by one or more of the factors listed earlier).

The implications for sealing procedures

A cracked basement is a symptom of some problem in the foundation wall, the floor, the surrounding soil, the drainage system, etc. If the crack is sealed, this provides a temporary remedy of the symptom, but it does nothing to stop the cause of the problem. The processes that caused the crack in the first place will tend to continue, and may cause further cracking that will destroy the sealing work.

When a cracked basement is encountered, the ideal course of action is to identify the cause of the cracking and put it right. This usually requires excavation around the outside of the foundation wall, and may involve upgrading of the weeping tile and drainage system, the use of a different type of backfill (such as gravel) around the foundation, the installation of damp-proofing or water-proofing on the exterior of the foundation wall, and so on. This type of work comes under the heading of rehabilitation rather than sealing. **In principle, it is advisable to rehabilitate a basement before attempting to seal it.** However, such rehabilitation work is expensive and so will require a decision on the part of the homeowner to bear the extra costs involved.

Basement cracks can be sealed without rehabilitation. In some cases this will give a good airtight seal for many years and solve other problems that arise from water seepage through the cracks. However, it is impossible to estimate how many cases will be successful in this way. Certainly, in some situations, the sealing work may open up within a very short period - weeks or months - due to continued deterioration of the basement.

On balance, it is worth sealing foundation cracks using the procedures given in this worksheet. Contractors should be aware, however, that if basement rehabilitation is not carried out, some of the sealing work may lose part of its effectiveness within a year or so.

Sealing techniques

Generally, it is advisable to seal foundation cracks on both the interior and the exterior where possible. If the cracks are sealed only on the interior, water and soil may build up in the cracks. This mixture may freeze and expand in winter, causing further opening of the crack. In most instances there is limited access to the exterior of the foundation wall, but advantage should be taken of whatever access there is. Specifically, most foundation walls have a certain amount of exposed area above ground level.

When sealing cracks from the interior, the techniques vary according to the size and distribution of the cracks and the type of foundation construction. This Worksheet presents two alternative procedures:

Procedure 1: Crack sealing.

Procedure 2: Whole wall sealing.

A cautionary note

When the various cracks are sealed around the floor and the foundation wall, air infiltration will be reduced. If there is a combustion unit in the basement, such as a furnace or a domestic hot water heater, an easy source of combustion air will have been lost. The furnace/heater will need to draw combustion air from other openings in the house envelope. The closest available air supply is through the floor drain, and the rate of air movement through this drain can therefore be expected to increase. This may introduce sewer gases into the house, and may also introduce radon gas in greater quantities. The severity of this problem has not been studied. In some houses it may be insignificant, but in other houses it may cause some air quality problems. Sealing contractors should be aware of this possible side effect. In some houses, where water is discharged periodically into the floor drain, this will maintain an adequate level of water in the water trap, and will virtually eliminate the problem. In other houses, a simple solution (though one with obvious limitations), is to remove the perforated cover from the drain and replace it with a solid metal cover, which can be removed easily and quickly when necessary.

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Procedure 1

CRACK SEALING

TOOLS

- Caulking gun
- Wire brush
- Knife
- Chisel
- Hammer

MATERIALS

As required and specified for each crack type.

This Procedure outlines techniques for sealing cracks in foundation walls and concrete floor slabs. It applies to concrete, unit masonry, and stone or marble construction, and is best used when the number of cracks to be sealed is modest.

Contractors should note that this Procedure is designed to achieve a good seal of the basement walls and floors in their current condition. Subsequent movement of the walls and floors may reduce the effectiveness of the seal, as discussed in the introduction to this Worksheet. As was also discussed in the introduction, it is advisable to seal foundation cracks on the inside and the outside, where possible.

This Procedure presents application techniques for three different crack size categories. For cracks of variable width, contractors should use their judgement to select a suitable combination of the three techniques.

PREPARATION:

1. In the case of large cracks (greater than 20mm in width), use a hammer and chisel to remove any loose pieces of material. For medium size cracks (8 to 20mm), use the hammer and chisel to chip out a reasonably uniform and regular surface in the crack.

2. For all cracks, including small ones that require no chisel work, clean the crack and the wall around it with a wire brush.

PROCEDURE 1 (continued)

CRACK SEALING

APPLICATION: Cracks less than 8mm in width

1. Inspect the surfaces to be sealed. Further work should not be conducted unless the crack is clear and dry.

2. One of the following materials must be used for sealing:

- High solids content butyl sealant with low sag properties (see Chapter 7); or
- Polysulphide sealant

3. If using butyl sealant, prepare the crack and surrounding surfaces by wiping with MEK (methyl ethyl ketone) or mineral spirits. If using polysulphide sealant, prepare the crack and surrounding area with polysulphide primer, as directed by the manufacturer.

4. Allow the solvent or primer to dry, then apply a continuous bead of sealant into the crack.

APPLICATION: Cracks 8 to 20mm wide

1. Inspect the surfaces to be sealed. Do not proceed unless the crack is clear and dry.

2. The following materials must be used for sealing:

- For horizontal cracks, use either polysulphide sealant or high solids content butyl sealant with low sag properties
- For vertical cracks, use only polysulphide sealant.

PROCEDURE 1 (continued)

CRACK SEALING

3. If using butyl sealant, prepare the cracks and surrounding surface by wiping with MEK (methyl ethyl ketone) or mineral spirits. If using polysulphide sealant, prepare the crack and surrounding surface with polysulphide primer, as directed by the manufacturer.

4. Work closed-cell backer rod into the crack, to form a firm backing for the sealant.

5. Allow the solvent or primer to dry, then apply a continuous bead of sealant into the crack.

APPLICATION: Cracks greater than 20mm in Width

1. Following the manufacturer's instructions, fill the crack as completely as possible with a water-stop type mortar (resin-based) or grout. See discussion of grouts in Chapter 7.

2. Inspect the repair after it has been allowed to dry. If small cracks have opened up, they can be sealed using the small crack technique presented above.

Procedure 2

WHOLE WALL SEALING

TOOLS

- Knife
- Caulking gun
- Wire brush
- Scraper
- Hammer or Hilti gun
- Putty knife
- Trowel
- Broom
- Staple gun

MATERIALS

- 0.150 mm polyethylene sheet, in 3048 mm width
- Sealant: acoustical or non-sag high solids content butyl rubber
- 19 x 64 mm wood strapping ("1 by 3's")
- Concrete nails or appropriate fasteners
- Concrete mortar mix or parge mix
- Small wood shims
- MEK (methyl ethyl ketone)
- Clean white rags
- Primer, if required
- Duct tape

This Procedure outlines two alternative techniques for sealing whole foundation walls that have porous surfaces and large areas of fine cracks. The "whole wall" techniques apply particularly to unit masonry construction (eg. concrete block walls) but may also be useful on poured concrete walls. The techniques presented here are not especially successful when applied to rubble/stone foundation walls, due to the highly uneven surfaces that are usually encountered.

The techniques presented involve either the sealing of the wall behind a sheet of polyethylene, or the parging of the wall. Before carrying out this work, **contractors should discuss with the householder the option of insulating the basement.** Specifically, there are a number of linkages between sealing and insulating that should be understood. For instance, if a sheet of polyethylene is installed as a sealing measure, and then at some later date the basement is insulated on the inside, the polyethylene will need to be cut or removed. On the other hand, if the interior insulation is installed sooner rather than later, the need for the whole wall air-sealing job is eliminated (if the insulation job is carefully sealed).

Two additional points should be noted. First, if the foundation wall cracks to be sealed leak water as well as air, the whole wall techniques may be inappropriate (depending upon the severity of the leakage). Also, as was noted in the introduction to this Worksheet, major cracks should be sealed on the outside as well as the inside of the foundation wall (to whatever degree possible).

PROCEDURE 2 (continued)

WHOLE WALL SEALING

PREPARATION:

(Steps 1-3 apply to both the parging and polyethylene techniques. Steps 4-6 apply only to the polyethylene technique.)

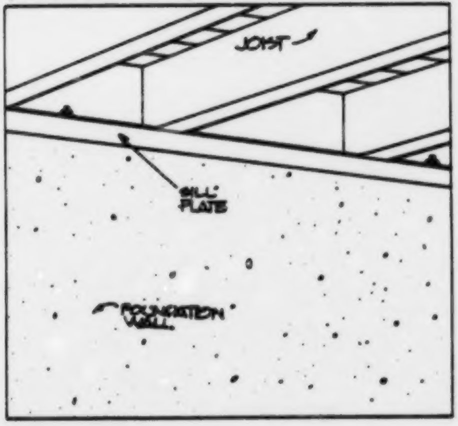
1. Brush wall surfaces with a broom to remove all dirt, efflorescence, dust, etc.

2. Seal any major cracks using the techniques given in Procedure 1.

3. Where possible, remove obstructions such as shelves.

4. Inspect wall surfaces and joints of wall and floor for irregularities. If there are large irregularities, such as in rubble walls, it may be difficult to attach polyethylene where required.

FIGURE 8.2



5. Determine if there is a continous wood frame member, such as a sill plate, that can be used for attaching the polyethylene at the top of the foundation wall (see Figure 8.2, and contrast it to Figure 8.4b later in this chapter). If there is a suitable wood frame member, clean the face of the wood with a wire brush and scraper. Wipe with MEK. Prime surface as required by the sealant manufacturer.

6. Clean the wall surface at floor level with MEK.

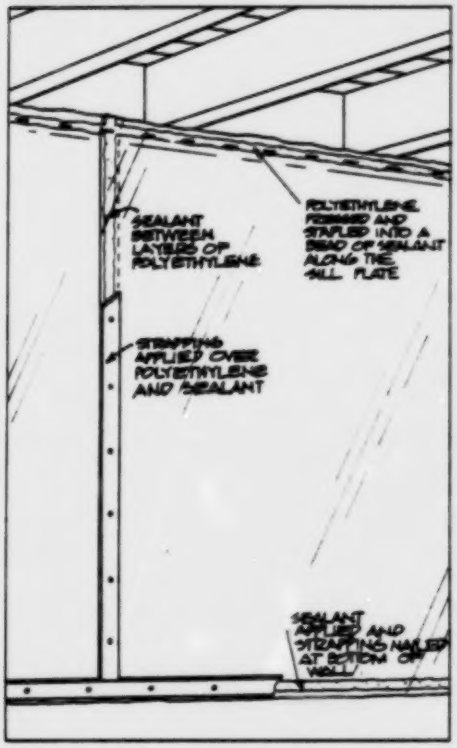
APPLICATION: Parging technique

1. Prepare and parge walls using standard techniques, as recommended by manufacturer of the selected parge type.

PROCEDURE 2 (continued)

WHOLE WALL SEALING

FIGURE 8.3


POLYETHYLENE PRESSED AND STAPLED INTO A BEAD OF SEALANT ALONG THE SILL PLATE
SEALANT BETWEEN LAYERS OF POLYETHYLENE
STRAPPING APPLIED OVER POLYETHYLENE AND SEALANT
SEALANT APPLIED AND STRAPPING NAILED AT BOTTOM OF WALL

APPLICATION: Polyethylene technique

(see Figure 8.3)

1. Apply a uniform and continuous bead of sealant to the face of the sill plate (or other continous and suitable wood surface).

2. Attach polyethylene sheet to the sill plate. Press the sheet into the sealant bead and staple every 150mm. Try to run the polyethylene continuously around the foundation wall, working around the various ducts, pipes, etc.

3. Overlap all vertical polythylene joints at least 150mm.

4. Trim the bottom of the polythylene, where necessary, so that there is about 150mm of space material at bottom of wall. Trim, as necessary, around such obstacles as windows.

5. Apply a continuous and uniform bead of sealant around the wall surface, 50mm above the floor level. Also apply sealant behind the edges of the polythelene where it has been trimmed around obstacles (window frames, etc.). Apply a continous and straight bead of sealant between all overlapping joints of polyethylene.

6. Press polyethylene to make good contact with sealant beads everywhere.

7. Apply strapping to the wall over the sealant beads, at floor level and at the vertical overlaps. Attach using concrete nails or appropriate fasteners. Shim if necessary.

8. Staple polyethylene around window frames, etc., through the line of sealant. Tape the polyethylene to pipes, applying pressure over the sealant bead.

PROCEDURE 2 (continued)

WHOLE WALL SEALING

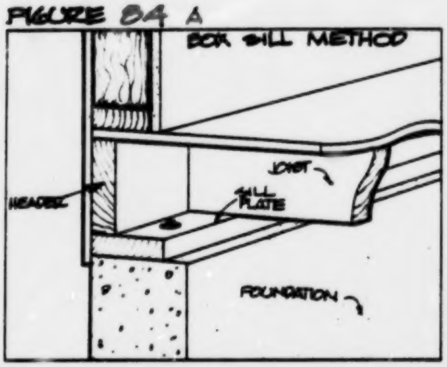
9. Trim excess polyethylene at floor level.

10. Repair any holes in the polyethylene using polyethylene patches and sealant.

Worksheet 2:
Procedures for sealing foundation/main floor joint

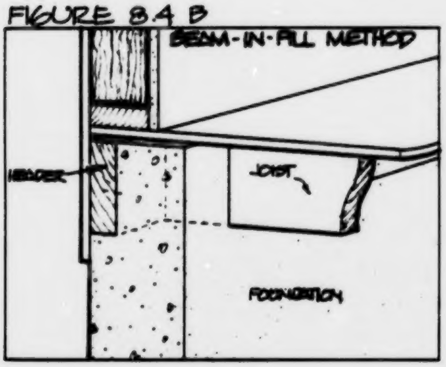
INTRODUCTION:

FIGURE 8.4 A



This Worksheet is concerned with air leakage at the top of the foundation wall, where the main floor joists and header are attached. A variety of types of construction are found at this point (see Figure 8.4). In some instances, the joist and header system are set on top of a sill plate. In other instances, the joists and header are set into the foundation wall, without a sill plate (a configuration known as beam-in-fill). For each of these general types of construction, there are many design variations.

FIGURE 8.4 B



This part of the house structure has several joints which may open up over a period of years. As a result, in many houses this area is one of the major sources of air leakage. If the basement is undeveloped, the junction between the foundation and the main floor is readily accessible and readily sealed. This Worksheet presents two general, alternative approaches:

Procedure 1: Sealing the junction between the foundation and the main floor.

Procedure 2: Sealing and insulating the junction between the foundation and the main floor.

The situation is more complicated when the basement has been partly or completely finished, since the top of the foundation wall becomes inaccessible (see Figure 8.5). For special cases where the ceiling materials adjacent to the foundation can be easily removed, Procedures 1 or 2 can be used. However, for most finished basements where the top of the foundation is truly inaccessible (unless major damage is done to the finished ceiling), this edition of this Manual provides

INTRODUCTION (continued)

FIGURE 8.5

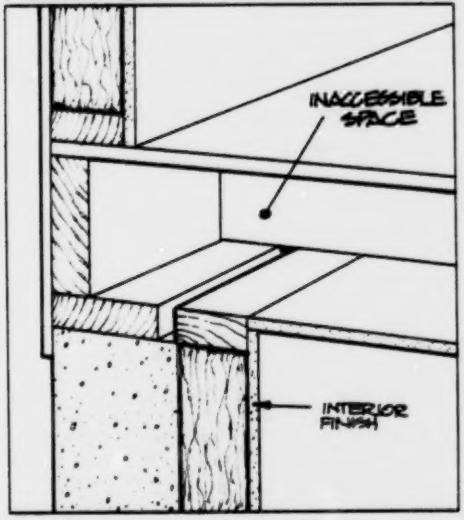
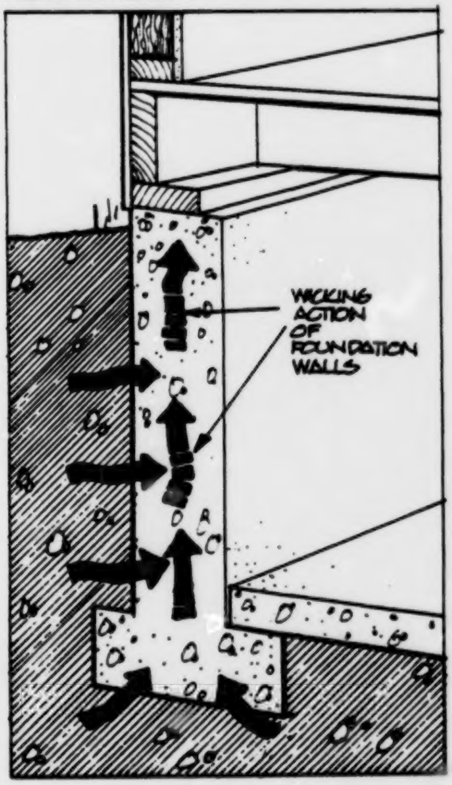


FIGURE 8.6



no specific procedures. This is a difficult area, for which no fully evaluated and completely satisfactory sealing technique is yet available (though there are promising approaches).

A cautionary note

The potential for moisture damage at the foundation/main floor intersection is often very high, depending on the structural details and the local climate. The problem arises because water can entered a masonry foundation wall through its various surfaces above ground and below. As shown in Figure 8.6, this water can move through the masonry by a process called capillary action (known commonly as wicking). The wicking action is particularly strong in mortar joints, such as those found in unit masonry or rubble walls. This wicking action may cause a high level of moisture at the top of the foundation wall, and may cause structural moisture damage to the wood frame sections in contact with the wall.

In leakier older houses, this moisture build up is counteracted by evaporation and by air leakage (infiltration) through the various structural joints at the top of the foundation wall. In other words, this air leakage may have a **beneficial** effect.

In cases where there is evidence of moisture build-up or structural moisture damage at the foundation and main floor intersection, there is a risk that the sealing procedures in the following Worksheets will aggravate the problem. Where there is any reason to suppose that moisture damage either exists, or might be induced by sealing, contractors are advised to omit the sealing work or, at least, to proceed with caution. A good procedure is to draw the attention of the homeowner to the problem, and recommend that remedial moisture protection work be conducted before sealing. Such remedial work would mainly consist of damp-proofing or water-proofing the foundation wall on the exterior (from the top of the wall to the footings, if possible).

INTRODUCTION (continued)

Moisture damage can also be aggravated by development work in the basement. When the basement has a finished stud-frame around the foundation wall and a finished ceiling, air circulation around the joist/header area is reduced. Thus, moisture that wicks through the foundation wall into this area might, in winter, accumulate as condensation or frost build-up at the top of the foundation wall. Thus, basement development can aggravate moisture problems. **Special care is therefore recommended before sealing foundation and main floor intersections in developed basements. It is important to assess the condition of the wood frame before proceeding with sealing.**

Procedure 1

SEALING THE JUNCTION BETWEEN THE FOUNDATION AND THE MAIN FLOOR

TOOLS

- Dust pan
- Small whisk broom
- Vacuum cleaner
- Wire brush
- Scraper
- Dispenser for urethane foam and/or caulking gun (depending on the particular job)

MATERIALS

- Sealant: water-based acrylic and/or non sag high solids content butyl rubber and/or polysulphide and/or urethane foam (depending on the particular job)
- Clean white rags
- Soap and water
  MEK (methyl ethyl ketone)
- Primer, if required

This Procedure outlines techniques for sealing the foundation at the point where it joins the main floor above, for those cases where the basement is unfinished. The general techniques are also suitable for use in some finished basements, if the ceiling close to the foundation can be easily removed. The techniques presented do not provide for insulation of the area being sealed.

The specific sealing techniques that should be used will vary from house to house, since the configuration of the joists, headers and other components varies. This Procedure outlines techniques for four types of configuration. Contractors should be able to adapt these techniques to suit other situations.

PREPARATION:

1. Inspect the foundation/main floor intersection to determine the construction design.

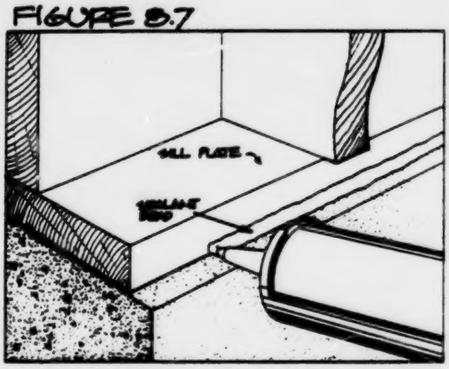
2. Using a small whisk broom, wire brush, and scraper, remove all loose concrete, old caulking, wood splinters, etc. from the top of the foundation wall and from the joist header cavity. Vacuum all surfaces to be sealed.

3. If urethane foam materials are to be used, no further surface preparation is required. For other sealants, wipe down the surfaces to be sealed using a rag wetted in soap and water. Allow to dry thoroughly.

4. Wipe all affected surfaces with MEK. Apply a primer if required by the sealant manufacturer.

PROCEDURE 1 (continued)
SEALING THE JUNCTION BETWEEN THE FOUNDATION AND THE MAIN FLOOR

FIGURE 8.7

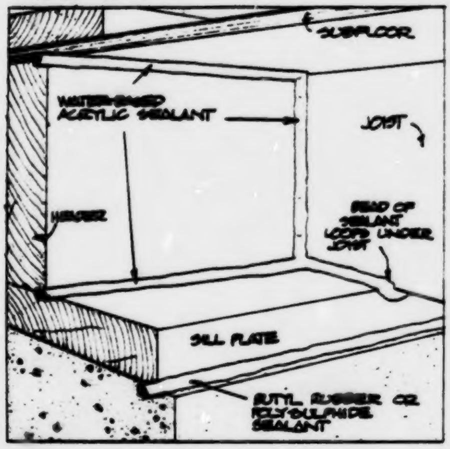

SILL PLATE
SEALANT BEAD

APPLICATION: Box sill

(Figure 8.4, previously presented, illustrates box sill construction.)

1. All around the foundation, apply a uniform and continous bead of high solids butyl rubber or polysulphide sealant to the joint between the top of the foundation wall and bottom of the sill plate, as shown in Figure 8.7.

FIGURE 8.8

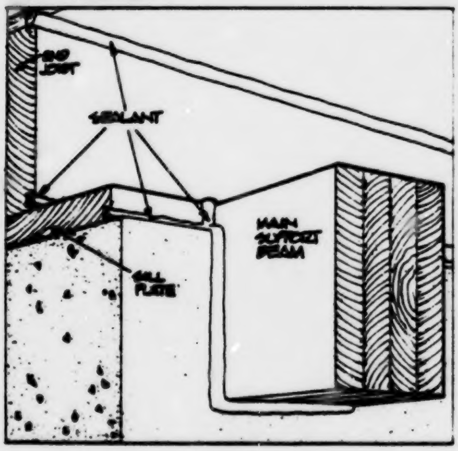

SUBFLOOR
WATER-BASED ACRYLIC SEALANT
JOIST
HEADER
BEAD OF SEALANT LOOPS UNDER JOIST
SILL PLATE
BUTYL RUBBER OR POLYSULPHIDE SEALANT

2. All around the foundation, apply a uniform and continuous bead of water based acrylic sealant at the joints between:

- the header and the sill plate
- the header and the subfloor
- the header and the joists
- the joists and the sill plate (including the little band under each joist).

Figure 8.8 illustrates the seals on a wall perpendicular to the joists. Walls parallel to the joists should also be sealed at the same points (except that the header/joist and joist/sill plate joints are only found on the "perpendicular" walls).

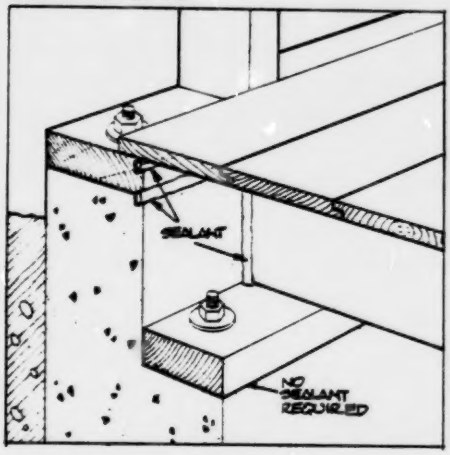
FIGURE 8.9


END JOIST
SEALANT
SILL PLATE
MAIN SUPPORT BEAM

3. Apply a uniform and continuous bead of non-sag high solids content butyl rubber or polysulphide sealant to joints around the main support beam where it meets the foundation wall, sill plate, and end joists, as shown in Figure 8.9.

PROCEDURE 1 (continued)
SEALING THE JUNCTION BETWEEN THE FOUNDATION AND THE MAIN FLOOR

FIGURE 8.10



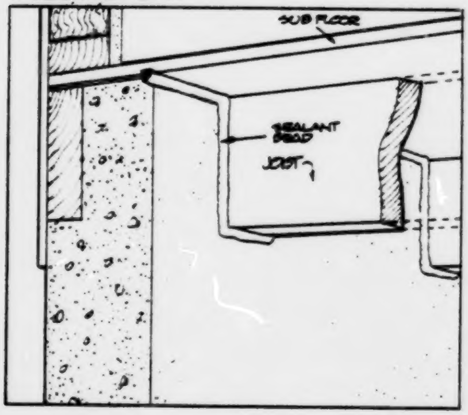
APPLICATION: Modified box sill

1. Figure 8.10 illustrates an alternative sill plate configuration.

2. There is no great value in sealing the lower plate. The upper plate should be sealed where it meets the subfloor, foundation, and joists. The joint between the foundation and the joists should also be sealed. Wood-to-wood and wood-to-masonry sealant selection should be as specified for a standard box sill.

3. Joints around the support beam should be sealed, adapting the box sill technique as appropriate.

FIGURE 8.11

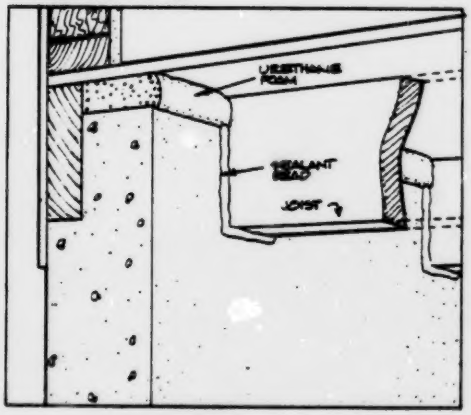


APPLICATION: Beam-in-fill

(Figure 8.4, previously presented, illustrates beam-in-fill construction)

1. If the space above the foundation is large enough to work in with a caulking gun, an adaptation of the box sill technique can be used. Otherwise, steps 2 or 3 should be followed.

FIGURE 8.12



2. If the space between the foundation and the subfloor is crack size, it can simply be sealed with high solids butyl rubber or polysulphide sealant, as shown in Figure 8.11.

3. If the space is larger - up to 100mm - the cavity can be completely filled with a one part or two part urethane foam sealant as shown in Figure 8.12. The figure also shows that the joint between the joists and the foundation should be sealed; again, urethane foam sealant can be used. Be careful to allow for expansion of the foam.

4. Joints around the support beam should be sealed, using an adaptation of the box sill technique presented above.

Procedure 2

SEALING AND INSULATING THE JUNCTION BETWEEN THE FOUNDATION AND THE MAIN FLOOR

TOOLS

- Staple gun
- Scissors
- Whisk broom
- Scraper
- Caulking gun
- Hand saw
- Square
- Hammer
- Tape measure

MATERIALS

- Sealant: water-based acrylic and acoustical
- MEK (methyl ethyl ketone)
- Clean white rags
- Fiberglass batt insulation
- 25 mm thick rigid insulation
- Staples
- 0.150 mm polyethylene sheet
- Nails

This procedure outlines two alternative techniques for sealing the junction between the foundation and the wall above. These techniques have the advantage of allowing insulation to be installed as a part of the sealing job. However, the general approach is not as versatile as that outlined in Procedure 1. Specifically, in the case of an unfinished basement, the techniques in this Worksheet generally apply only to box sill-type construction (refer back to Figure 8.4). Procedure 2 can also be applied in the case of finished basements, if the basement ceiling can be easily removed to allow access to the area above the foundation wall.

Of the two techniques presented in this Procedure, the rigid insulation technique results in slightly higher insulation levels. However, when rigid insulation materials are used, some form of fire protection (such as drywall) must be provided. In the case of a finished basement (with the ceilings temporarily removed to provide access for these sealing measures), the ceiling may provide suitable protection when it is replaced. If not, and in cases where there is no ceiling, appropriate protection should be installed. In such cases, the polyethylene technique presented in this Procedure may be a more flexible option.

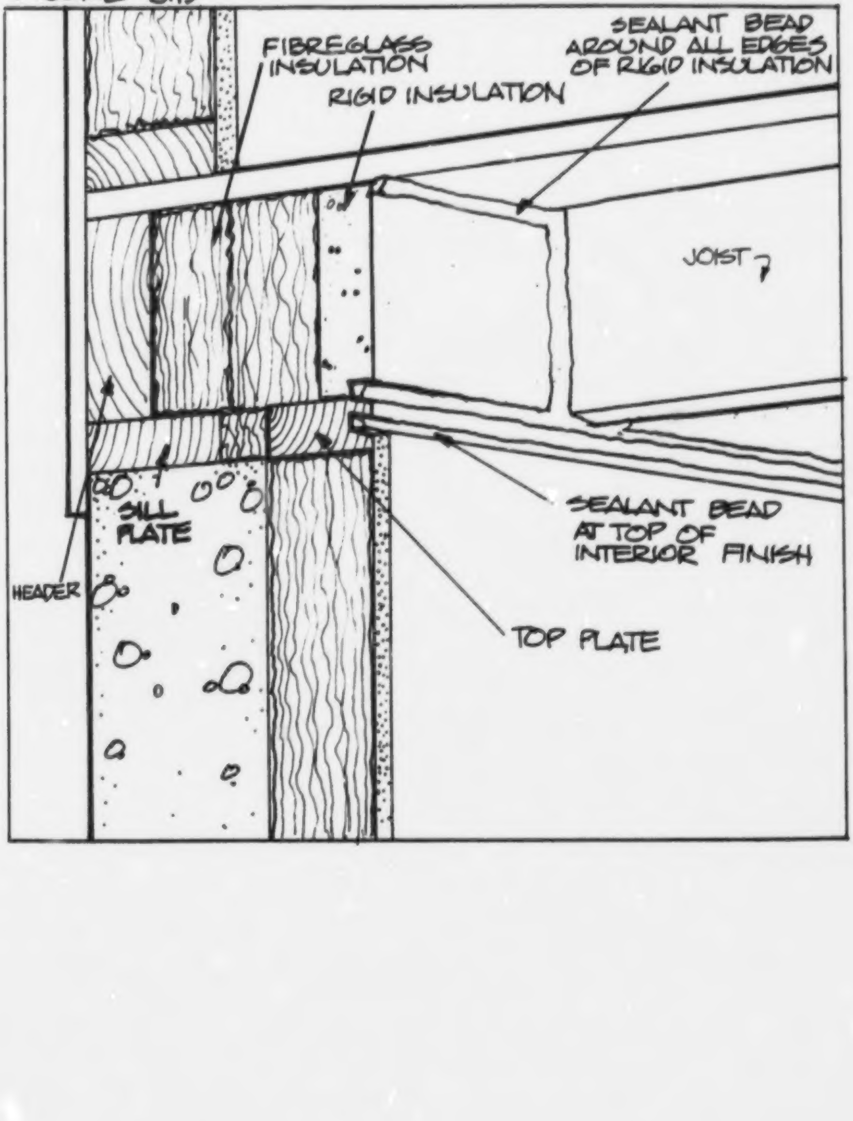
For convenience, the description that follows refers to the specific case of a finished basement in which suitable ceiling access has been provided. The approach for unfinished basements is similar.

PREPARATION:

1. Using a whisk broom and scraper, clean all surfaces to which any sealant must adhere.

2. Wipe the surfaces with a clean white rag soaked in MEK.

FIGURE 8.13


FIBREGLASS INSULATION
RIGID INSULATION
SEALANT BEAD AROUND ALL EDGES OF RIGID INSULATION
JOIST
SILL PLATE
HEADER
SEALANT BEAD AT TOP OF INTERIOR FINISH
TOP PLATE

PROCEDURE 2 (continued)

SEALING AND INSULATING THE JUNCTION BETWEEN THE FOUNDATION AND THE MAIN FLOOR

APPLICATION: Rigid insulation technique

(See Figure 8.13)

1. Seal the joints in the subfloor above each cavity that is to be insulated and sealed. Unless the gaps are large, water-based acrylic sealant can be used.

2. Apply a bead of sealant at the joint between the interior finish and the top plate, if this area is not already well sealed. (In the case of an unfinished basement, apply a bead of high solids butyl rubber or polysulphide sealant to the joint between the foundation wall and the sill plate.)

3. Fill the cavities above the foundation wall with fibreglass batt insulation.

4. Cut pieces of rigid board insulation to fit snugly into the spaces between the floor joists, subfloor, and top plate of the finished stud wall.

5. Push the rigid board insulation into place between the floor joists.

6. Apply a uniform and continuous bead of acoustical sealant at the joints between the rigid insulation board and the surrounding wood surfaces.

7. Install suitable fire protection over the rigid insulation, as required by local fire codes. The ceiling over a finished basement, when re-installed, may be sufficient.

8. The above steps refer to the foundation wall running perpendicular to the joists. The walls running parallel to the joists may be more difficult to seal, particularly if access to the space above the foundation wall is restricted.

PROCEDURE 2 (continued)
SEALING AND INSULATING THE JUNCTION BETWEEN THE FOUNDATION AND THE MAIN FLOOR

Adaptation of this rigid insulation technique may be feasible; if not, contractors may be able to utilize the techniques presented in Procedure 1 of this Worksheet.

APPLICATION: Polyethylene technique

(See Figure 8.14)

1. Do steps 1, 2, and 3 of the rigid insulation technique, above.

2. Cut oversize pieces of polyethylene sheet material, for insertion into the spaces above the top plate.

3. Apply a uniform and continuous bead of acoustical sealant to the subfloor, joists and top plate surfaces, where each polyethylene sheet is to be installed.

4. Press the polyethylene sheet material into the bead of sealant at the subfloor. Staple through the polyethylene and the acoustical sealant to fix the sheet in place.

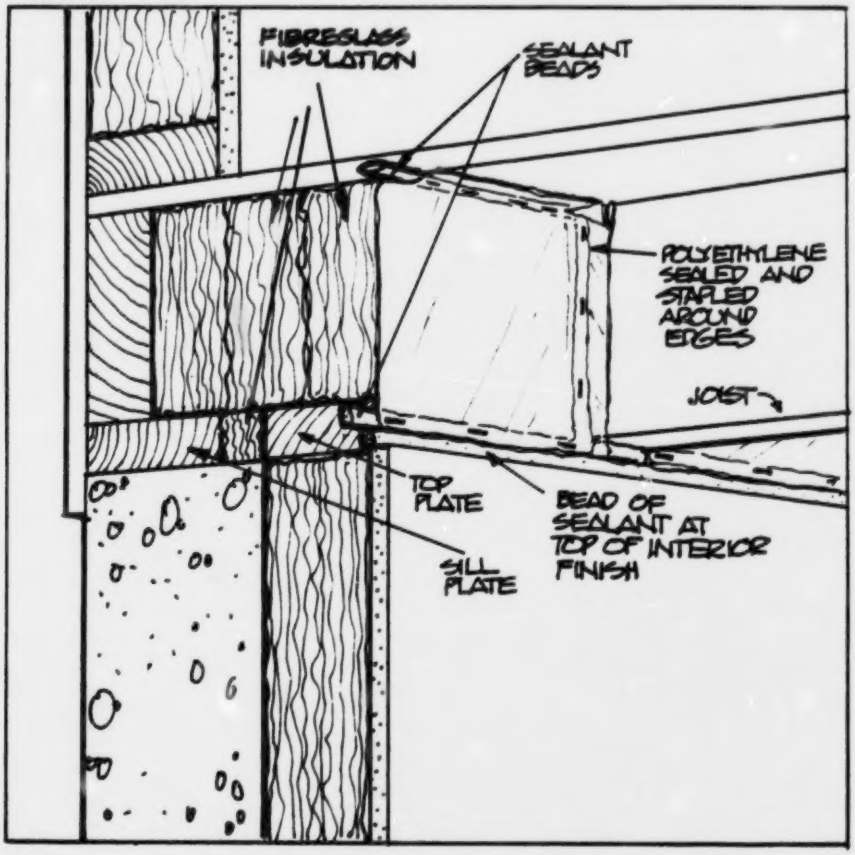
5. Continue to press the polyethylene sheet material into the bead of sealant at the floor joists and top plate of the finished wall. Be sure to provide a well bonded and tight fit. Staple through the polyethylene and acoustical sealant.

6. For mechanical protection, install drywall, panelling or other rigid materials over the polyethylene.

PROCEDURE 2 (continued)
SEALING AND INSULATING THE JUNCTION BETWEEN THE FOUNDATION AND THE MAIN FLOOR

7. The above steps refer to the foundation wall running perpendicular to the joists. The walls running parallel to the joists may be more difficult to seal, particularly if access to the space above the foundation wall is restricted. Adaptation of this polyethylene technique may be feasible; if not, contractors may be able to utilize the techniques presented in Procedure 1 of this Worksheet.

FIGURE 8.14


FIBREGLASS INSULATION
SEALANT BEADS
POLYETHYLENE SEALED AND STAPLED AROUND EDGES
JOIST
TOP PLATE
BEAD OF SEALANT AT TOP OF INTERIOR FINISH
SILL PLATE

Worksheet 3:

Procedures for sealing penetrations through the foundation

INTRODUCTION:

In addition to cracks through the foundation (Worksheet 1) and the gaps at its top (Worksheet 2), there are a number of deliberate penetrations through most foundations. This Worksheet is concerned with the sealing of such penetrations in the specific case of unfinished basements. The areas in question are:

Windows and exterior doors

Most basements have windows and some also have exterior doors (sometimes accessed from the outside via a hatch and a flight of steps). These windows and doors can generally be treated using normal window/door sealing techniques, but with some special considerations. Firstly, basement windows/doors tend to be of a lower quality than other windows/doors in the house, and they tend to suffer more from moisture damage (due to their closeness to ground level). Therefore, before such units can be properly sealed, it is often necessary to spend some time and effort repairing them. Secondly, most basement windows and doors can be expected to have large air leakage cracks between the frame and the surrounding foundation wall. These gaps are of a very different character than the gaps around a standard window or door. Consequently, the standard sealing techniques presented in Chapters 12 and 13 are inappropriate. Instead, techniques adapted to the basement situation should be used:

Procedure 1: Sealing window and door frames in foundation walls.

Service entrances, vents and ducts

A wide variety of pipes and ducts pass through most foundation walls, including, for instance:

- Gas service inlets
- Electrical service inlets
- Oil pipes
- Water inlets
- Water pipe connections to exterior taps
- Dryer vents
- Built-in house vacuum system exhausts
- Fresh air intakes.

The size of the air leakage gaps around these features varies considerably, depending on the quality of the installation. In total, they can contribute a significant amount to the total air leakage heat losses of the house - but they can also be successfully sealed:

> **Procedure** 2: Sealing around ducts, vents, and service entrances.

(**Note** that the techniques outlined in Procedure 2 cover pipe and duct penetrations of the header, as well as penetrations of the masonry foundation.)

Large openings

Many older house have some kind of hatch or coal chute passing through the foundation wall. Such openings were used when the house was heated with solid fuels - but in most cases the houses have now been converted to oil, gas, or electrical heating. Often, some attempt has been made to close in the opening, but the work may be of poor quality, and the air leakage through the blocked-in opening can be high. This Worksheet outlines a suitable sealing technique:

Procedure 3: Sealing large openings such as coal chutes.

Procedure 1

SEALING WINDOW AND DOOR FRAMES IN FOUNDATION WALLS

TOOLS

- Caulking gun
- Scraper
- Wire brush

MATERIALS

- Sealant:
  high solids content butyl rubber or polysulphide
- Concrete or wood primer, if required
- Backer rod material (polyethylene)
- Clean white rags
- MEK (methyl ethyl ketone)

(Additional tools and materials may be required if minor repairs are necessary)

This Procedure outlines techniques for sealing the joints between foundation walls and the frames of any windows or doors. **In addition** to the procedures presented here, contractors should refer to the window/door sealing procedures outlined in Chapters 12 and 13.

PREPARATION:

1. Thoroughly clean the concrete or masonry/wood frame joint with a wire brush and scraper, removing all loose particles.

2. Wipe the wood frame with a rag soaked in MEK.

3. Apply suitable concrete and wood primer, if required by the sealant manufacturer.

APPLICATION:

1. Where the joint between the frame and the foundation wall is less than 8mm, simply apply a bead of sealant to the joint.

2. Where the joint is 8-19mm wide, insert backer rod material to leave a joint depth not greater than 6mm. Apply a continuous bead of sealant over the backer rod, being careful to make a good seal between the wall and the frame.

Procedure 2

SEALING AROUND DUCTS, VENTS AND SERVICE ENTRANCES

TOOLS

- Caulking gun
- Scraper
- Wire brush

MATERIALS

- Steel wool
- Clean white rags
- MEK (methyl ethyl ketone) or mineral spirits
- Sealant:
  high solids content butyl and/or polysulphide and/or water-based acrylic and/or silicone (depending upon the job)
- Duxseal
- Backer rod
- Primer, if required

(Additional tools and materials may be required if minor repairs are necessary)

This Procedure outlines techniques for sealing air leakage openings around the various pipes and ducts that pass through the exposed foundation wall or through the floor header at the top of the foundation wall. These techniques should generally be applied on the inside of the wall, if possible.

In most cases, a fairly standard set of sealing measures is applicable, regardless of whether the pipe or duct is a dryer vent, water pipe, gas inlet, etc. Electrical service entrances, however, are a special case (see Figure 8.15). In addition to the air leakage gap around the service conduit, the conduit tube itself is a source of air leakage (since the cables do not totally block the tube). Special additional techniques are therefore presented for this leakage point.

PREPARATION:

1. For those pipes and ducts that pass through the foundation wall, clean dirt and loose material from the surrounding wall using a wire brush.

2. For those pipes/ducts that pass through a floor header, attempt to clean the surrounding surface of the header using a scraper.

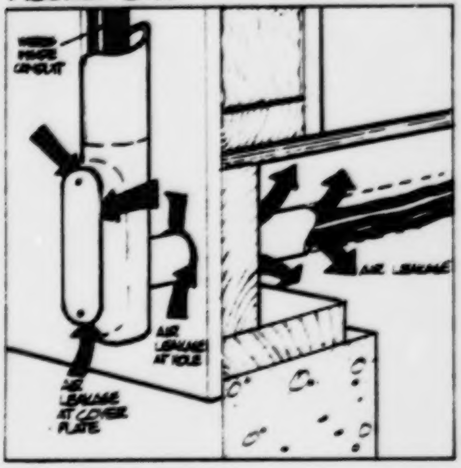
3. Using steel wool, clean the surface of the pipe or duct adjacent to the wall.

4. Wipe the working area with MEK or mineral spirits. (Use only mineral spirits when plastic or rubber surfaces or electric wiring are involved.) Apply primer if required by the sealant manufacturer.

PROCEDURE 2 (continued)

SEALING AROUND DUCTS, VENTS AND SERVICE ENTRANCES

FIGURE 8.15



APPLICATION: General

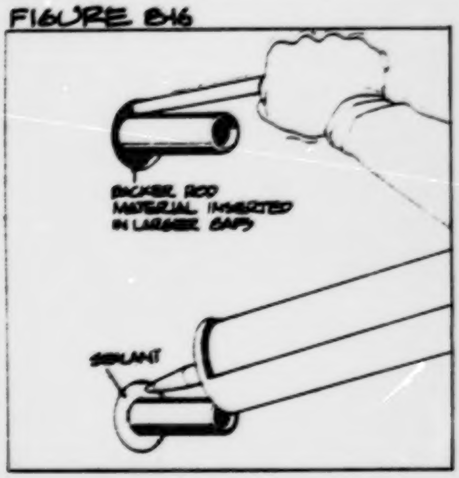
(See Figure 8.16)

1. If there is a large gap around the duct, pipe, etc., insert backer rod material.

2. If the duct, pipe, etc. passes through a concrete or masonry wall and the gap exceeds 3mm, apply a continous bead of polysulphide sealant. If the gap is smaller, apply either polysulphide or high solids content butyl sealant.

3. If the duct, pipe, etc. passes through a wood header, seal the gap with (in order of preference) acrylic, silicone, or high solids butyl sealant.

FIGURE 8.16


BACKER ROD MATERIAL INSERTED IN LARGER GAPS
SEALANT

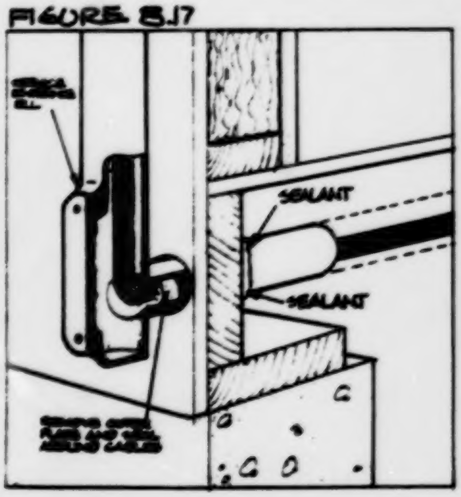
APPLICATION: Electrical service inlets

(See Figure 8.17)

1. If the service conduit is easily accessible where it passes through the foundation wall or header, it should be sealed using the general techniques above. In some cases, however, the conduit may pass through the foundation wall straight into the back of the service panel, making the air gap inaccessible from the inside. In this case, the above sealing techniques should be applied on the outside of the foundation wall.

2. Where applicable, remove the cover plate from the exterior service entrance ell. Apply sealant around cables to make an airtight seal, using an approved sealant type such as Duxseal. **Note that great caution should be taken when working in this area, and that all local codes and regulations should be followed. In some jurisdictions, only licensed persons can perform this work.**

FIGURE 8.17



Procedure 3

SEALING LARGE OPENINGS SUCH AS COAL CHUTES

TOOLS

- Caulking gun
- Scraper
- Wire brush
- Pry bar
- Hammer
- Knife
- Stapling gun
- Scissors

MATERIALS

- Pressure treated plywood, 12 mm as required
- 0.150 mm polyethylene
- Glass fibre batt
- Galvanized nails
- Sealant: construction adhesive, acoustical, and one of polysulphide or high solids low sag butyl
- MEK (methyl ethyl ketone)
- Clean white rags
- Primer, if required

(Additional tools and materials will be required for exterior finishing and perhaps for repairs).

This Procedure outlines techniques for sealing unused large openings such as old coal chutes, boarded-up windows, etc. The description assumes that the opening is rectangular, has a wood frame inside it, and is closed off with a board nailed to the exterior of the frame as shown in Figure 8.18. If the opening to be sealed is constructed differently, the following techniques should be adjusted accordingly.

PREPARATION:

1. Remove the cover. Inspect the frame and the cover, to determine if they are in good enough condition to be retained. (If not, provide a new frame or cover as required.)

2. Prepare the interior working face of the frame and the joint between the frame and the wall (on the interior) by thoroughly cleaning the area with a wire brush and scraper. Wipe the surface with a rag soaked in MEK, and apply a primer if required by the sealant manufacturer.

3. Clean the exterior working face of the frame exterior with a wire brush to remove dirt, oil, etc. Do the same to the cover. Wipe working surface with MEK.

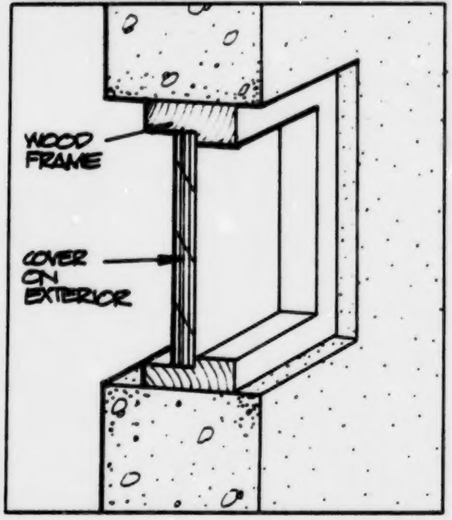
APPLICATION:

1. Apply continous bead of construction adhesive to the exterior working face of the frame.

2. Nail the cover back in position using galvanised nails.

PROCEDURE 3 (continued)
SEALING LARGE OPENINGS SUCH AS COAL SHUTES

FIGURE 8.18



3. The exterior can then be finished to match the existing foundation wall surface (using wire lath and parge, for instance). Alternatively, the joint between the frame and the surrounding wall should be sealed with solvent-based acrylic sealant (after suitable surface preparation). Exposed wood surfaces should be painted.

4. Working from the inside, install glass fibre batt insulation to completely fill the frame.

5. Run a continous bead of acoustical sealant around the interior working face of the frame.

6. Cut a section of 0.150mm polyethylene to fit the space. Press it against the sealant bead and staple through the sealant at 150mm spacing.

7. Cover the frame with 12mm plywood, preferably pressure-treated, nailed in place with galvanised nails.

8. Fill the gap between the frame and the surrounding wall with either polysulphide sealant or high solids, low-sag butyl sealant.

Chapter 9:
Floors over Unheated Spaces

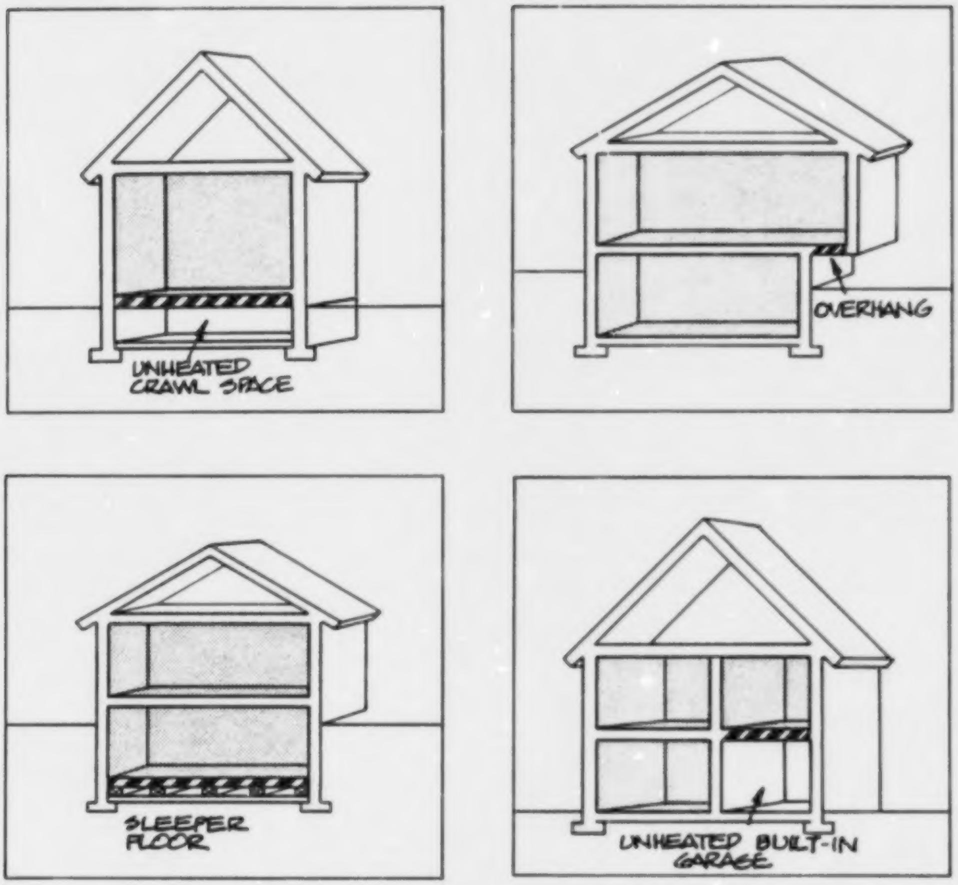
INTRODUCTION

Floors over unheated spaces include such types of construction as sleeper floors, overhangs of various types, and floors above unheated crawl spaces or built-in garages (see Figure 9.1). **These structures are part of the house "envelope"**, and as such can be sources of considerable air leakage into the heated interior.

This chapter discusses a number of sealing techniques suitable for application to many such floors. It should be realized, however, that the contractor will sometimes encounter other, unusual circumstances that will require the use of additional techniques (some of which will be covered in future editions of this Manual).

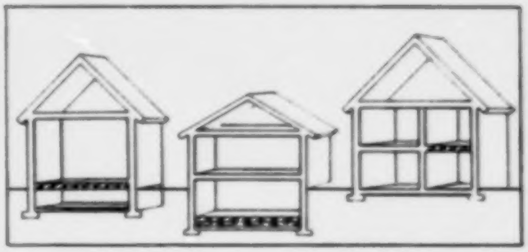
For definitions of specialized terminology, refer to the glossary at the end of this Manual.

FIGURE 9.1

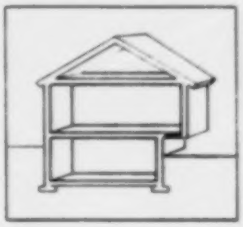

UNHEATED
CRAWL SPACE
OVERHANG
SLEEPER
FLOOR
UNHEATED BUILT-IN
GARAGE

GUIDE TO THE WORKSHEETS

This chapter contains two Worksheets:



Procedures applicable to most **FLOORS OVER UNHEATED SPACES** . . . . . . Worksheet 1



Special procedures applicable to **OVERHANGS** . . . . . . Worksheet 2

The Worksheets describe appropriate sealing procedures step-by-step, including preparation and application requirements. The necessary tools and materials are identified in each case. **For most floor sealing jobs, it will be necessary to refer to either of Worksheets 1 or 2, but not to both.**

Worksheet 1:

Procedures applicable to most floors over unheated spaces

INTRODUCTION:

Sealing floors over unheated spaces, where there is no continous vapour barrier, requires attention to two types of gap:

Gaps where pipes, ducts, cables, etc. pass through the floor

A variety of "service penetrations" may pass through the floor, either directly into the rooms above, or into partition walls, cupboards, etc. These require sealing at the point of penetration.

Heating system ducts (both warm air and return air) may also penetrate the floor above an unheated space, generally at the end of a run through the unheated space. The air circulating in these ducts is part of the heated house air - so the ducts themselves should be sealed where they run through the unheated space (if accessible). In addition, the points where the ducts penetrate through the floor should be sealed.

This Worksheet outlines appropriate procedures for these various types of work:

Procedure 1: Sealing floor penetrations above unheated spaces.

Gaps between floor boards

Gaps between floorboards may or may not be a significant air leakage problem. Some types of floorings - vinyl sheet flooring and tiles, for instance - serve as air barriers if in good condition. In such cases, if gaps in the floor covering are repaired (by replacing lifted tiles; applying a specially manufactured floor covering seal; etc.), satisfactory control of air leakage through the floor surface can be expected. Note that this does not generally affect the desirability of carrying out the work described in Procedure 1 of this Worksheet and in Chapter 10 of this Manual (for sealing of the floor/exterior wall joint).

In the case of other floors, there may be several air leakage gaps and no effective covering to reduce the leakage through these gaps. An example is an old carpet laid over a lapboard floor. In this situation, the best procedure is to install a sealed polyethylene air-vapour barrier across the floor, then to protect this barrier by installing a new underlay (eg. particle board) over the vapour barrier. This approach is described in this Worksheet:

> **Procedure 2:** Installation of air-vapour barriers on floors above unheated spaces.

In many cases, installation of an air-vapour barrier will leave some air leakage gaps of the sort covered in Procedure 1 of this Worksheet (for instance, pipes running from the unheated space into partition walls). If accessible, a thorough sealing job should include application of Procedure 1 techniques to these gaps.

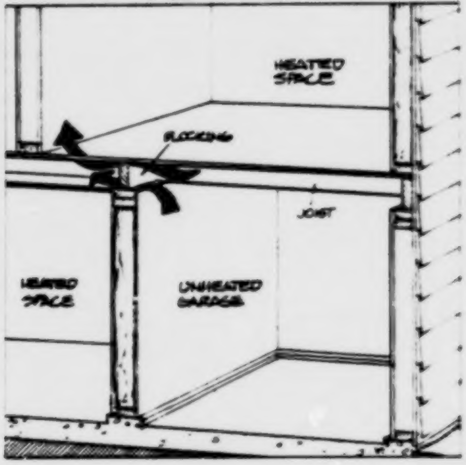
It should be noted that Procedure 2 provides a floor seal and a seal between the floor and the wall. Therefore, when Procedure 2 is applied, the baseboard and floorboard sealing techniques outlined in Chapter 10 are generally unnecessary.

Special cases

The procedures presented in this Worksheet can be reasonably effective in reducing leakage through floors. However, it should be noted that, in some

INTRODUCTION (continued)

FIGURE 9.2



cases, floors over unheated spaces create a special problem in the joist space below. Specifically, if the joist space connects to an adjacent, heated, part of the house, air leakage along the joist space may be significant. Figure 9.2 illustrates the situation in the case of a built-in garage; somewhat similar problems can arise in the case of an overhang.

Worksheet 2 considers an overall approach to the problem of sealing an overhang, including both the floor and the joist space. However, the unheated garage problem is not discussed in detail in this edition of this Manual. In general, the approach is to seal the floor above the garage as described in this Worksheet. In addition, the problem of sealing air leakage through the joist area into the heated interior should be addressed when sealing the wall between the garage and the main house (in accordance with the procedures discussed in Chapters 8 or 10, as appropriate).

Unfortunately, the joist area directly above the wall, where this sealing work is required, is very often inaccessible. As a result, proper sealing of this problem area may not be feasible in many cases.

A cautionary note

Before a floor over an unheated space is sealed, contractors should ensure that the work will not cause moisture problems.

The example of an unheated crawl space illustrates the potential problem. Ideally, the space under the floor should be ventilated, and any surface below ground level, such as foundation walls or exposed soil, should be provided with some form of moisture barrier. Often, however, there is no ventilation or moisture barrier. In such cases, the air leakage through the floor may be beneficial to the house structure, since it carries moisture from the crawl space into the house, and thus prevents a build-up of moisture in the unheated area.

If sealing is applied to such a floor, the air infiltration is reduced considerably. This could therefore promote an increase of moisture levels in the unheated space, possibly leading to structural damage of any wood frame in the area.

In view of these facts, **if an unheated space under a floor has no system for moisture control, except for air infiltration through the floor, it is inadvisable to conduct sealing work without first providing proper moisture control in the unheated space.** In the case of a crawl space, such moisture control may consist of the installation of a polyethylene moisture barrier across an exposed soil floor, or the use of a bitumen-based moisture barrier "paint" on foundation walls. Air vent systems may also be installed around the foundation wall, but if this is done it is advisable to install vents that can be closed for winter operation.

A similar principle applies in the case of a sleeper floor on a concrete slab. In the case of an unsealed floor, moisture from the slab may be able to escape through the sleeper floor into the room air. On the other hand, if the floor is sealed, this moisture would be trapped in the sleeper floor structure, where it can lead to rotting and deterioration of the wood (and to odour problems). Consequently, **sleeper floors should only be sealed where the floor has been constructed of pressure treated wood and where a 0.10mm polyethylene moisture barrier has been installed between the wood sleeper floor and the concrete pad.**

Procedure 1

SEALING OF FLOOR PENETRATIONS ABOVE UNHEATED SPACES

TOOLS

- Knife
- Wire brush
- Scraper
- Stapler
- Caulking gun
- Scissors
- Blunt tool
- Paper stapler

MATERIALS

- 50 mm wide duct tape
- 0.150 mm polyethylene sheet
- Sealant: water-based acrylic and acoustical
- Foil-faced glass fibre insulation
- Closed cell backer rod
- Steel wool
- Oakum
- Clean white rags
- MEK (methyl ethyl ketone) or mineral spirits

This Procedure outlines techniques for sealing gaps around cables, pipes, heating system ducts, and other penetrations that pass through floors over unheated spaces.

If the underside of the floor is accessible, the heating system duct penetrations should be sealed from below. Other penetrations that are inaccessible from above (pipes running up through the floor into partition walls for instance) should also be sealed from below, if the underside of the floor is accessible. All remaining pentrations should be sealed from above the floor, if possible.

Three techniques are presented - one for heating system ducts and the other two for other types of penetration. Refer to the cautionary note in the introduction to this Worksheet before proceeding with this work.

PREPARATION:

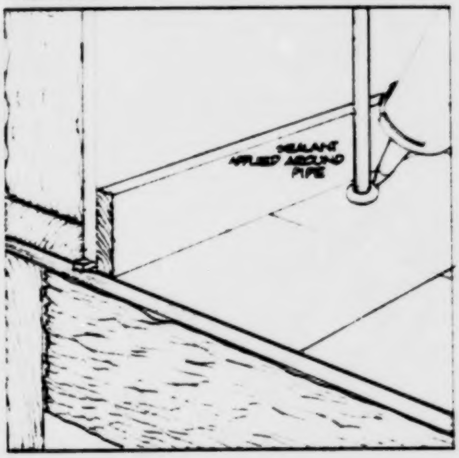
1. The following surface preparation steps should be carried out from above the floor or from below, depending upon where the seal is to be applied.

2. Ensure that any heating ducts are securely fastened in place.

3. Use a wire brush and scraper to clear loose paint, wood splinters, and dirt from the floor surface around any pipe or other penetration through the floor.

4. In the case of copper, iron, or steel service penetrations, clean the metal with steel wool, wherever sealant is to be applied. Wipe the metal and the adjacent floor with MEK.

FIGURE 9.3

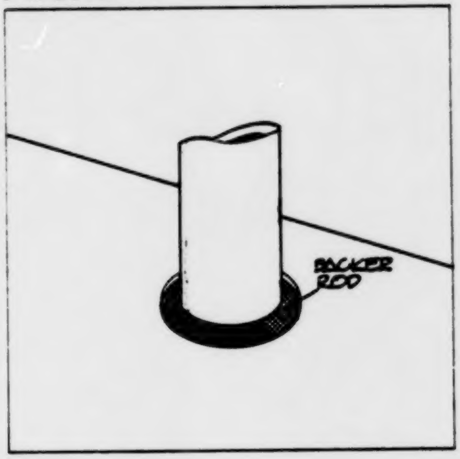


5. In the case of other types of penetrations simply use MEK or mineral spirits to wipe all pipe and duct surfaces that are to be sealed, and to wipe the adjacent floor. Use mineral spirits - not MEK - for plastic or rubber surfaces and for electrical wiring.

6. In the case where heating system ducts run through the unheated space below the floor, clean all joints in the ducts by wiping with MEK (if accessible).

APPLICATION: Pipes and other service penetrations/sealant technique

FIGURE 9.4



1. This technique can be applied to either the top or bottom of the floor, depending upon accessibility.

2. If the gap around the service penetration is 8mm or less, apply a uniform and continuous bead of water-based acrylic sealant in the gap, as shown in Figure 9.3.

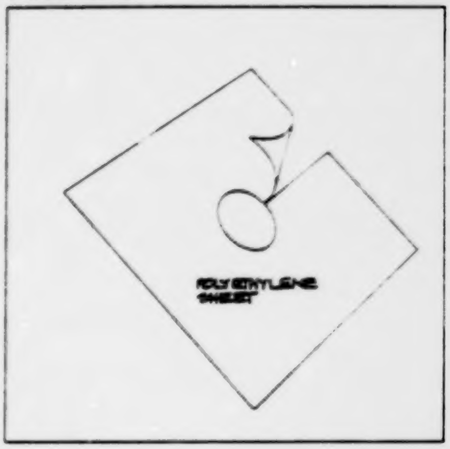
3. If the gap around the service line is 8-12mm, use a blunt tool to install a closed cell backer rod material having a diameter 25% larger than the width of the joint. Install to a depth of 8mm below the floor surface, as shown in Figure 9.4. Apply a uniform and continuous bead of water-based acrylic sealant over the backer rod material, in the joint around the service penetration. Finger tool as required.

4. If the gap around the service line is larger than 12mm, or if the pipe/service line is subjected to a large amount of movement (due to thermal expansion or contraction), fill the joint with oakum. Note that this technique is effective only when there is an adequate depth of hole to secure the oakum.

PROCEDURE 1 (continued)

SEALING OF FLOOR PENETRATIONS ABOVE UNHEATED SPACES

FIGURE 9.5



APPLICATION: Pipes and service penetrations/polyethylene technique

1. This technique should be applied to the underside of the floor. It is suitable for large gaps.

2. Cut an oversized piece of polyethylene sheet. Cut a hole in the centre of the sheet slightly larger than the diameter of the service line, then slit to the center from one side, as shown in Figure 9.5.

3. From the underside of the floor, apply a uniform and continous bead of acoustical sealant to the floor, around the edge of the opening. Apply another bead in a band around the service line, a small distance below the floor.

4. Place the polyethylene sheet around the service line and press into the sealant. Wrap duct tape around the service line over the polyethylene and sealant, extending over the free, lower edge of the polyethylene.

5. Apply sealant between the overlapping layers of polyethylene (along the slit) and staple the layers together, through the sealant, with a paper stapler.

6. Press the polyethylene material into the acoustical sealant on the floor. Staple through the polyethylene and sealant into the wood subfloor, as shown in Figure 9.6.

APPLICATION: Heating system ducts

1. This work is carried out beneath the floor, if accessible. It applies to both warm air and return air ducts.

PROCEDURE 1 (continued)

SEALING OF FLOOR PENETRATIONS ABOVE UNHEATED SPACES

2. Apply 50mm duct tape to all joints in the ducts, including joints between the ducts and the subfloor, as shown in Figure 9.7. Staple the duct tape to the sub-floor.

3. Insulate the complete duct system (in the unheated space) by wrapping the ducts with foil-faced glassfibre insulation material. The foil should face to the cold side. Tape the joints in the insulation using 50mm duct tape.

FIGURE 9.6

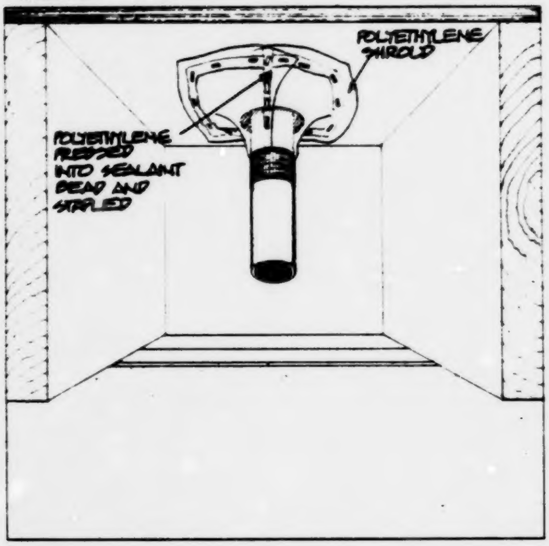
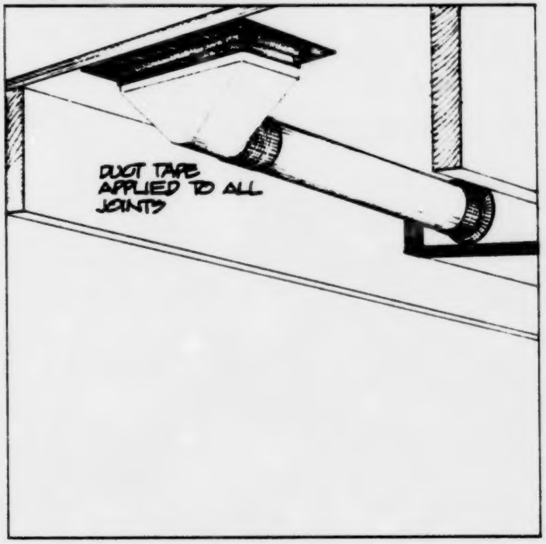

POLYETHYLENE SHROUD
POLYETHYLENE PRESSED INTO SEALANT BEAD AND STAPLED

FIGURE 9.7


DUCT TAPE APPLIED TO ALL JOINTS

Procedure 2

INSTALLATION OF AIR-VAPOUR BARRIERS ON FLOORS ABOVE UNHEATED SPACES

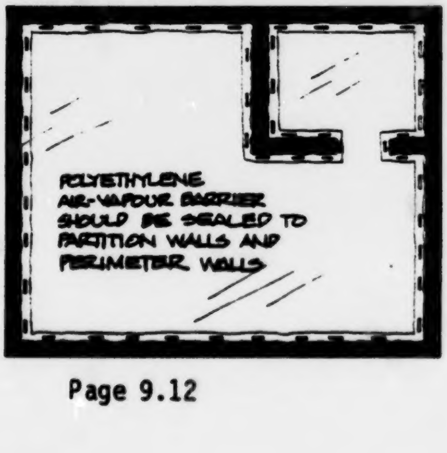
TOOLS

- Caulking gun
- Scissors
- Hammer
- Scraper
- Broom
- Vacuum cleaner
- Knife
- Pry bar
- Staple gun
- Tape measure
- Saw

MATERIALS

- 0.150 mm polyethylene sheet
- Sealant: acoustical
- Nails
- 19 mm particle board sheet material (low formaldehyde type)
- Staples
- MEK (methyl ethyl ketone)
- Clean white rags

FIGURE 9.8



This Procedure outlines techniques for sealing a floor above an unheated space by completely covering it with an air-vapour barrier. In order to give as tight a seal as is reasonably practicable, the procedure requires that the barrier be sealed, at its edges, to the perimeter and partition walls (as illustrated in Figure 9.8 for an example floorplan). Note that this Procedure is not appropriate to all situations; the Introduction to this Worksheet discusses the circumstances in which the techniques can be used.

PREPARATION:

1. Remove any old carpeting and inspect the existing floor surface. Determine if any repair work is required to provide a solid and smooth working surface. Such repairs might involve the nailing down of any loose floor boards and additional nailing to ensure a firm base for the particle board that will be installed. In addition, if a finished floor is also to be installed, the old floor surface may need sanding to remove high spots that would cause noticeable irregularities in the finished floor.

2. If the walls around the floor have baseboards, remove these with a pry bar. If necessary, first use a knife to score the paint along the wall/baseboard joint, so as to avoid paint chipping and peeling.

3. Clean the complete floor surface using a broom and vacuum cleaner. At the walls, use a scraper to remove loose material.

4. Using rags soaked in MEK, wipe the wall surface just above the floor, and the floor surface close to the wall.

PROCEDURE 2 (continued)

INSTALLATION OF AIR-VAPOUR BARRIERS ON FLOORS ABOVE UNHEATED SPACES

APPLICATION:

(See Figures 9.9 and 9.10)

1. If the walls are of wood-frame construction, apply a uniform and continous horizontal bead of acoustical sealant on the wall surface at the baseboard level. Apply a second uniform and continous bead of acoustical sealant to the floor surface. This bead should be close to the wall, so that it will be concealed when the baseboard is re-installed.

2. If the walls are of concrete or masonry construction, apply a uniform and continous bead of acoustical sealant into the corner joint where the wall and floor intersect.

3. Measure and cut the polyethylene sheet material into appropriate lengths, allowing for some slack at the joints where the wall and floor intersect. Also allow extra material between sheets of polyethylene, in order to allow an overlapping joint.

4. The job of installing this polyethylene sheet involves several steps, as noted below. These should be carefully organized so as to minimize the degree to which it is necessary to walk on the polyethylene.

5. Press the edges of the polyethylene sheet material into the sealant to form a good seal. Every 150 mm, staple through the polyethylene and sealant into the floor (and into the bottom plate in the case of wood frame walls).

6. Apply a continuous bead of acoustical sealant between the overlapping layers of polyethylene, at each joint between sheets. Every 150mm, staple through the polyethylene and sealant into the floor, as shown in Figure 9.11.

FIGURE 9.9

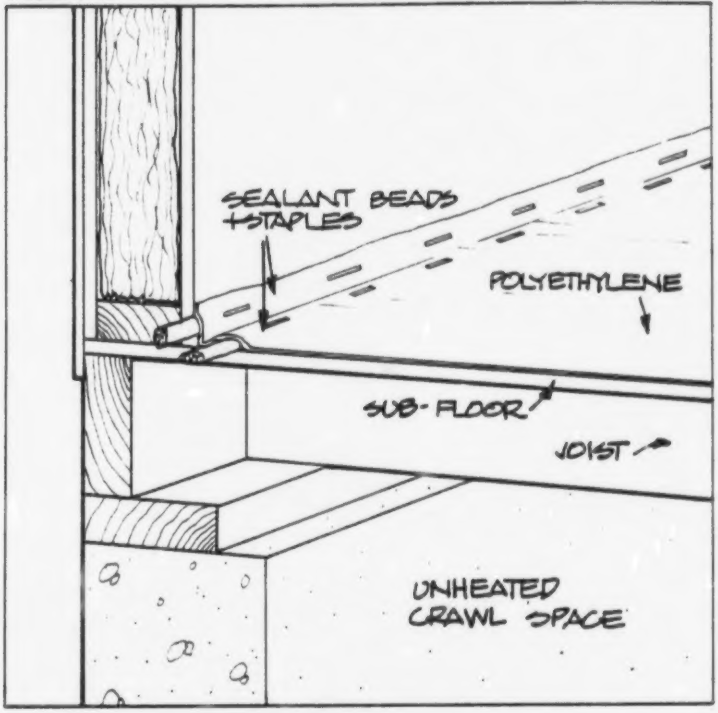
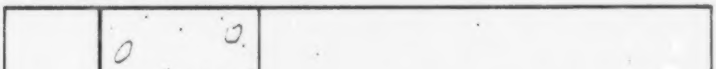

SEALANT BEADS
+STAPLES
POLYETHYLENE
SUB-FLOOR
JOIST
UNHEATED
CRAWL SPACE

FIGURE 9.10


SEALANT BEAD AND
STAPLE IN CORNER
POLYETHYLENE
SLEEPER
FLOOR
PRESSURED
TREATED
WOOD
MOISTURE
BARRIER

PROCEDURE 2 (continued)

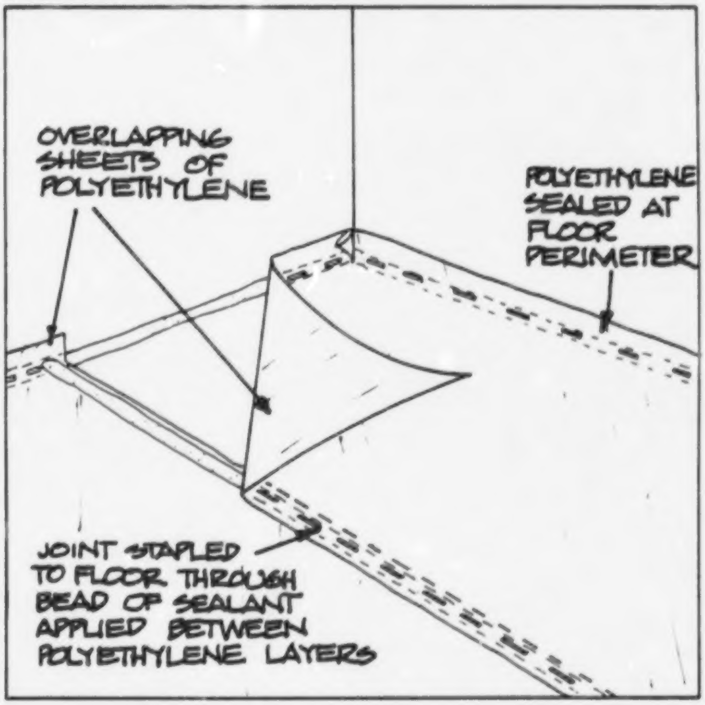
INSTALLATION OF AIR-VAPOUR BARRIERS ON FLOORS ABOVE UNHEATED SPACES

7. Repair any holes or tears in the polyethylene sheet material using patches of polyethylene and acoustical sealant. Staple through polyethylene and sealant as required to provide a good seal.

8. Apply 19mm particle board on top of the polyethylene sheet material to provide a protective cover and a smooth firm base for the finish floor materials. Nail or staple as required.

9. Re-install baseboards where applicable. Trim off excess polyethylene material if required.

FIGURE 9.11


OVERLAPPING SHEETS OF POLYETHYLENE
POLYETHYLENE SEALED AT FLOOR PERIMETER
JOINT STAPLED TO FLOOR THROUGH BEAD OF SEALANT APPLIED BETWEEN POLYETHYLENE LAYERS

Worksheet 2:
Special procedures applicable to overhangs

INTRODUCTION AND PROCEDURES

Figure 9.12 illustrates a typical overhang construction. Because it has not been customary to install a vapour barrier on the floor above the overhang, and because the plywood finish underneath is usually poorly installed, most overhangs allow considerable leakage. This leakage involves air movement through the floor above and along the joist space. Both of these paths require sealing measures.

Because of the many design variations that are encountered in overhang construction, this Worksheet (unlike most of the others in this Manual) does not present a set of specific procedures. Instead, a general approach is outlined below; contractors will need to carefully adapt it to the circumstances they encounter.

GENERAL APPROACH:

(Refer to Figure 9.13)

1. Remove the plywood finish underneath the overhang.

2. Cut sections of rigid impermeable foam insulation. The sections should be sized to fit tightly into the spaces above the sill plate, between each pair of joists.

3. Press the sections into position so that they are flush with the sill plate, as shown in Figure 9.13. If the basement has been finished, the foam sections should be installed as shown in Figure 9.14.

FIGURE 9.12

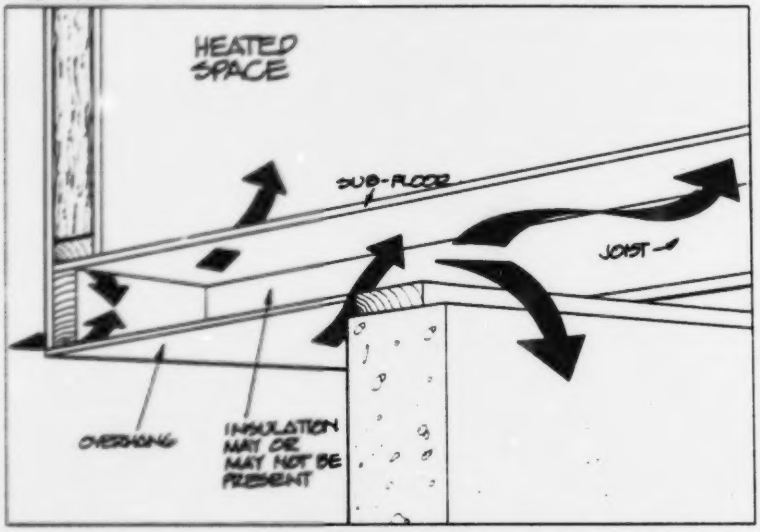
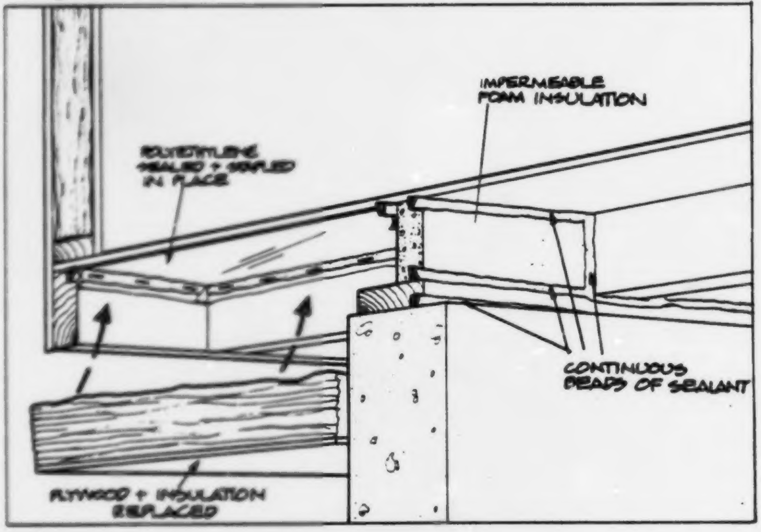

HEATED SPACE
SUB-FLOOR
JOIST
OVERHANG
INSULATION MAY OR MAY NOT BE PRESENT

FIGURE 9.13


IMPERMEABLE FOAM INSULATION
POLYETHYLENE SEALED + STAPLED IN PLACE
CONTINUOUS BEADS OF SEALANT
PLYWOOD + INSULATION REPLACED

INTRODUCTION AND PROCEDURES (continued)

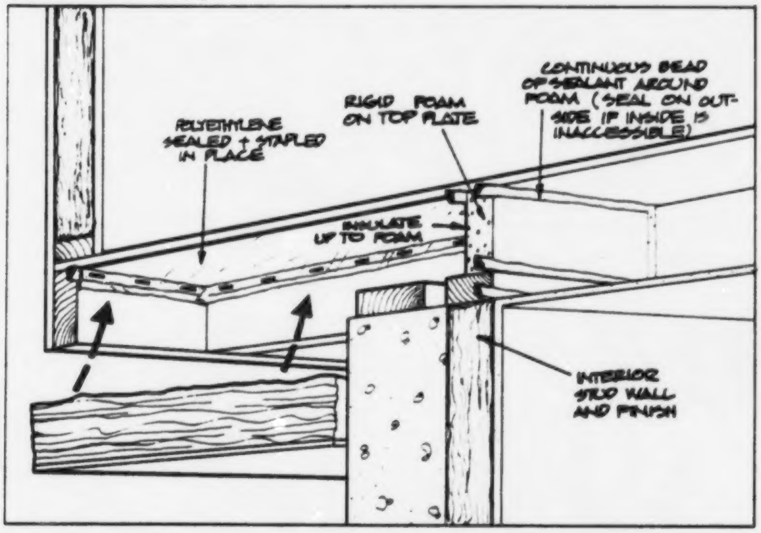
4. Apply a continous bead of sealant around the eges of the foam insulation, to make a seal with the sub-floor, the floor joists and the sill plate.

5. Working from outside, install a strip of 0.150mm polyethylene on the underside of the sub-floor, between each pair of floor joists. This strip should be sealed with acoustical sealant and stapled around the edges, to give an airtight seal to the joists, floor header, and foam inserts.

6. Fill the joist cavities fully with batts of glass fibre insulation.

7. Replace the plywood cover under the joists. If the rigid insulation is exposed to the basement, pieces of drywall should be installed on the inside to provide fire protection.

FIGURE 9.14


POLYETHYLENE SEALED + STAPLED IN PLACE
RIGID FOAM ON TOP PLATE
CONTINUOUS BEAD OF SEALANT AROUND FOAM (SEAL ON OUT-SIDE IF INSIDE IS INACCESSIBLE)
INSULATE UP TO FOAM
INTERIOR STUD WALL AND FINISH

Chapter 10:
Exterior Walls

FIGURE 10.1

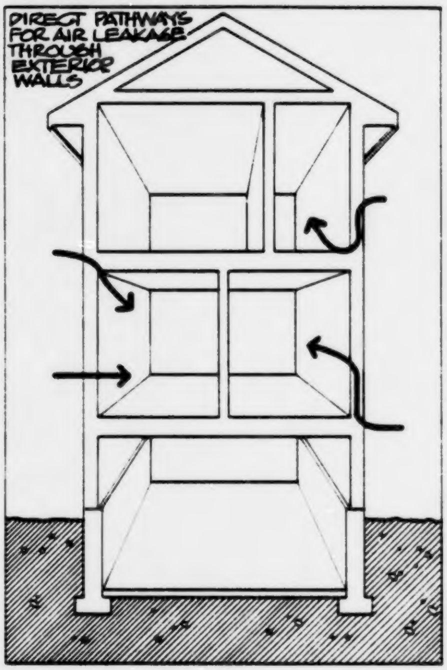
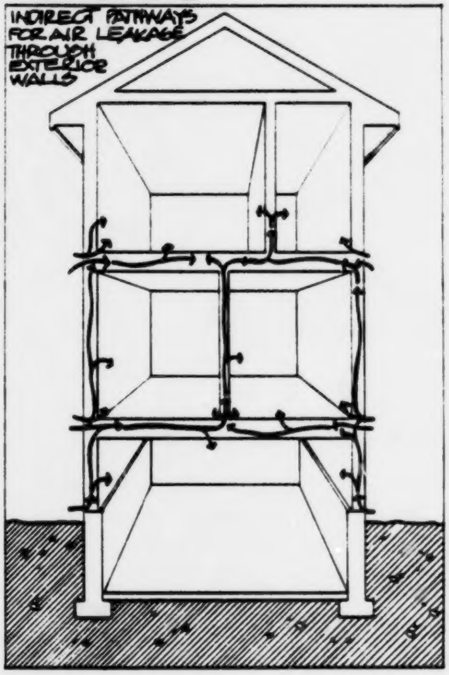


FIGURE 10.2



Informally, air leakage through exterior walls can be thought of as falling into two categories: direct and indirect. Figures 10.1 and 10.2 illustrate the distinction between the two air leakage patterns. Air passing into an exterior wall from the outdoors might escape *directly* into the heated rooms via baseboard cracks, switches, and so on. Alternatively, the air might escape to the heated rooms more *indirectly*, travelling along partition walls and enclosed intermediate floors before emerging far from the exterior walls. *In most houses, both types of air leakage are significant*.

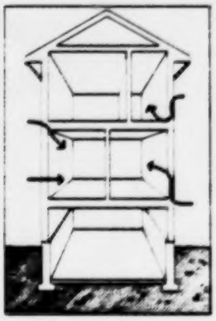
Different sealing approaches are required for these two types of exterior wall air leakage. Direct leakage can be reduced by carrying out sealing work on or near the inside face of the exterior walls -- work that could be called direct sealing. On the other hand, the reduction of indirect leakage requires work in various other parts of house -- work that could be called indirect sealing. This chapter considers both direct and indirect sealing of exterior walls.

It should be noted that many houses have some form of vapour barrier in their walls. The once common type of barrier that was attached to batts of insulation does not have a great impact on air leakage, since such a barrier has so many gaps. On the other hand, a more continuous barrier, such as polyethylene, can *in principle* significantly reduce air leakage. Unfortunately, conventional building practice has not paid much attention to vapour barrier installation. The result has been that houses with vapour barriers can still be leaky, since the barriers are commonly broken at just those points where air leakage would normally be expected (electrical receptacles, bottom plates of walls, at partition walls, etc). In short, contractors should be aware that in a few well-constructed houses, little wall sealing may be needed. However, in most cases the existence of a vapour barrier does not eliminate the value of sealing most of the usual wall leakage points.

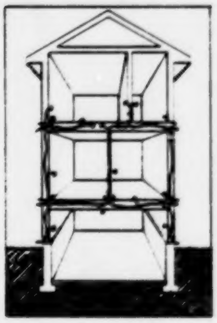
For definitions of specialized terminology, refer to the glossary at the end of this Manual.

GUIDE TO THE WORKSHEETS

The following pages contain 2 Worksheets:



Procedures for
direct sealing of
EXTERIOR WALLS . . . . . . Worksheet 1



Overview of indirect
sealing of
EXTERIOR WALLS . . . . . . Worksheet 2

The specific procedures identified in Worksheet 1 are relevant to any wall sealing job. The discussion in Worksheet 2 should be reviewed, though at this time it is not generally suggested that indirect sealing be a standard element of the air sealing of exterior walls (see Chapter 5).

Worksheet 1:
Procedures for direct sealing of exterior walls

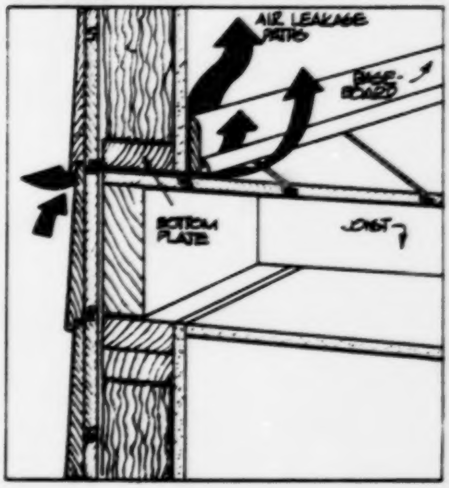
INTRODUCTION:

With respect to exterior walls, there are basically five air leakage problem areas that can, potentially, be directly sealed:

- Doors and windows
- Gaps between the bottom plate of the wall and the floor
- Electrical receptacles (switches and outlets)
- Cracks and gaps in the drywall or plaster, including the joint between the wall and ceiling
- Gaps between floor boards where they penetrate the wall.

Windows and doors are covered in Chapters 12 and 13 respectively. This Worksheet considers procedures for sealing the other problem areas:

FIGURE 10.3



Gaps between the bottom plate of the wall and the floor immediately below will allow air leakage into the house, since air can generally seep around the baseboard (see Figure 10.3). This problem can be resolved in either of two fashions:

Procedure 1: Sealing the baseboard without removal.

Procedure 2: Sealing the bottom plate behind the baseboard.

Note that these procedures can also be used at the bottom plate of a slab-on-grade house - often an important air leakage point in these structures. Note also that the sealing of the subfloor, as

discussed below, is conveniently undertaken in conjunction with the sealing described in Procedure 1 or 2.

Electrical receptacles (switches and outlets) are common in the exterior walls of houses. Together, these make a considerable contribution to the total air leakage of the house. The air leakage through these receptacles is very pronounced when the house is being subjected to airtightness tests, and contractors will find it instructive to conduct smoke pencil tests on the receptacles at this time.

Electrical receptacles usually consist of metal boxes with several cable entries, screw holes, and unused punchout holes. These, together with the gap that usually exists between the receptacle and the drywall, make up a considerable leakage area. The electrical codes are very stringent on the matter of sealing receptacles. Nothing should be introduced into the receptacle that could increase the risk of combustion or generate toxic fumes in the event of fire. This excludes practically all common sealants and vapour barrier materials, but certain special products are available and are easily installed:

Procedure 3: Sealing electrical receptacles.

Drywall/plaster cracks are common in older houses. Sometimes these are caused by movement or settlement of the house structure, and occur preferentially along wall corners or along the corners of walls and ceilings. Sometimes the cracks may be the result of moisture damage, such as occurs below windows that suffer from condensation effects. In some cases (notably corners) the cracks may be hidden behind moulding.

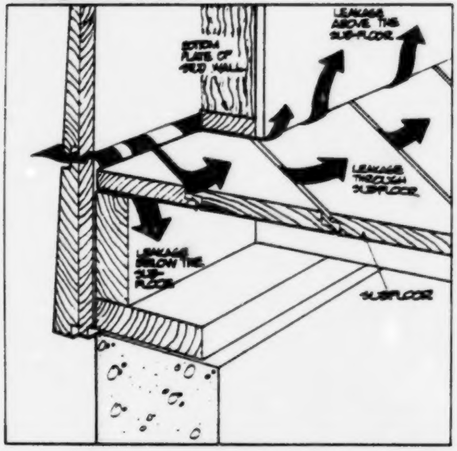
In addition to cracks resulting from deterioration, deliberate gaps may be found in the wall finish. For instance, in many houses built around 1945-50, the drywall joints were left untaped at corners.

The gaps, which were often as wide as 12mm, were concealed with corner moulding of various types. Over the years this moulding may have pulled away from the corners and left air leakage gaps.

These types of leakage points can be readily sealed:

> **Procedure 4**: Sealing drywall/plaster cracks and gaps.

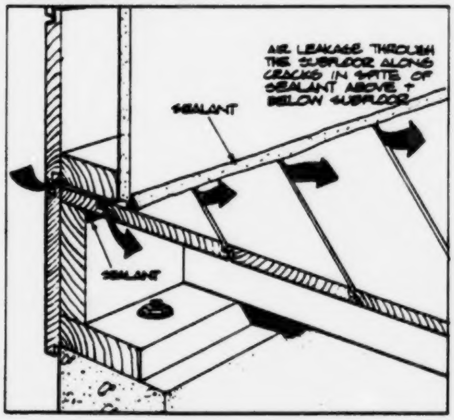
FIGURE 10.4


BOTTOM PLATE OF STUD WALL
LEAKAGE ABOVE THE SUB-FLOOR
LEAKAGE THROUGH SUBFLOOR
LEAKAGE BELOW THE SUB-FLOOR
SUBFLOOR

Gaps between floorboards, where they penetrate the exterior wall, will allow very direct air leakage into a great many houses. To understand the problem, it is necessary to examine the wall structure, as shown for platform frame construction in Figure 10.4. In such houses, three distinct air leakage paths exist in very close proximity:

- Leakage above the subfloor (i.e., between the bottom plate of the wall and the subfloor)
- Leakage below the subfloor (i.e., between the header and the subfloor)
- Leakage through the subfloor, along the gaps at subfloor joints.

FIGURE 10.5


AIR LEAKAGE THROUGH THE SUBFLOOR ALONG CRACKS IN SPITE OF SEALANT ABOVE + BELOW SUBFLOOR
SEALANT
SEALANT

The first of these paths is discussed above and in Procedures 1 and 2 of this Worksheet. The second path is discussed in Chapter 8 of this Manaul (for the case of the main floor header). Note, however, that sealing these two leakage paths, though necessary, does nothing to stop leakage along the third path, as shown in Figure 10.5.

The problem is most severe in an older house with subfloors made of board of various types, including tongue-and-groove and lapboard. (This is the situation illustrated in Figures 10.4 and 10.5.) In modern construction, subfloors are made of sheet material such as plywood, resulting in fewer joints and less leakage.

INTRODUCTION (continued)

Sealing this general air leakage problem is not always feasible, but it can be done in many cases, as outlined in this Worksheet:

Procedure 5: Sealing gaps between floorboards.

EXTERIOR WALLS:
WORKSHEET 1
continued

Procedure 1

SEALING THE BASEBOARDS WITHOUT REMOVAL

TOOLS

- Caulking gun
- Hammer

MATERIALS

- Sealant: water based acrylic (coloured to match)
- Clean white rags
- Mineral Spirits or soap and water
- Finishing Nails

This Procedure outlines techniques for the sealing of the bottom plate of an exterior wall by sealing around the baseboards. It leaves exposed sealant, and so may be visually unacceptable in some circumstances.

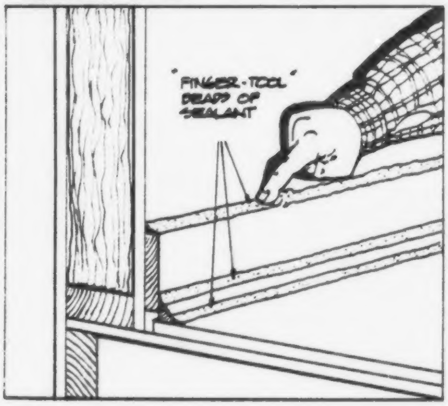
PREPARATION:

1. Inspect the gaps adjacent to all baseboards and associated wood mouldings (i.e. between the baseboard and the wall; baseboard and the floor; baseboard and the moulding; corners; etc.).

2. Using a wood block as a protective covering, hammer all baseboards firmly into position. Provide additional nailing if the baseboard is not firmly fastened.

3. Clean all cracks and joints to be sealed using a clean white rag wetted in mineral spirits or soap and water solution. Ensure that wall and floor surface materials are compatible with the cleaning solvent or solution to be used.

FIGURE 10.6



APPLICATION:

1. Apply a needle bead of sealant to all cracks and joints 3mm or less. With a wetted finger, smooth the surface bead to give an attractive finish.

2. Apply a uniform and continuous bead of sealant to all cracks or joints larger than 3mm. With a wetted finger or some suitable tool, smooth the surface bead to match surrounding contours, as shown in Figure 10.6.

PROCEDURE 1 (continued)

SEALING THE BASEBOARDS WITHOUT REMOVAL

3. Clean all excess sealant materials from working surfaces with a wet white rag.

Procedure 2

SEALING THE BOTTOM PLATE BEHIND THE BASEBOARD

TOOLS

- Caulking gun
- Hammer
- Prybar
- Side cutters
- Pliers
- Putty knife
- Wire brush
- Knife

MATERIALS

- Sealant: water-based acrylic or urethane foam (one or two part)
- MEK (methyl ethyl ketone) or mineral spirits
- Clean white rags
- Backer rod material, if required
- Finishing nails

This Procedure outlines two alternative techniques for the sealing of the bottom plate of a wall after removing the existing baseboards. These approaches can be used instead of Procedure 1 if exposed sealant around the baseboard is unacceptable to the householder, or if the baseboards are to be removed for other work (such as Procedure 5 of this Worksheet).

PREPARATION:

1. Carefully remove each baseboard and the associated moulding strips, using a pry bar. If necessary, first use a knife to score the paint at the wall/baseboard junction, in order to prevent paint chipping and peeling.

2. Remove any remaining nails in the baseboard or moldings by cutting them off using side cutters, or pull the nails through using pliers.

3. In order to simplify re-installation, mark the original location on each length of baseboard and molding material.

4. If the floor is covered with carpet, ensure that there is sufficient access to the gap to be sealed. If not, lift the carpet away from the wall and off the nailer strips.

5. Clean dirt and loose material from the wall and floor surfaces using a wire brush. Wipe with MEK or mineral spirits.

PROCEDURE 2 (continued)
SEALING THE BOTTOM PLATE BEHIND THE BASEBOARD

APPLICATION: Foam technique

1. If the gap between the wall and floor surface is in excess of 8mm wide and 8mm in depth, apply a bead of quick setting one or two part urethane foam sealant into the joint between the wall and floor, as shown in Figure 10.7. **Be careful to limit the amount of sealant used**, since the foam expands.

2. Re-install the baseboard before the urethane foam has set, nailing firmly into position. Remove any excess foam material.

3. Note that this technique must only be applied with the consent of the homeowner. The baseboard will become strongly bonded to the urethane foam, making future removal of the baseboard difficult. If this is unacceptable, the exposed foam can be allowed to cure. A putty knife or special tool can then be used to trim the foam flush, following which the baseboards can be replaced.

APPLICATION: Acrylic sealant technique

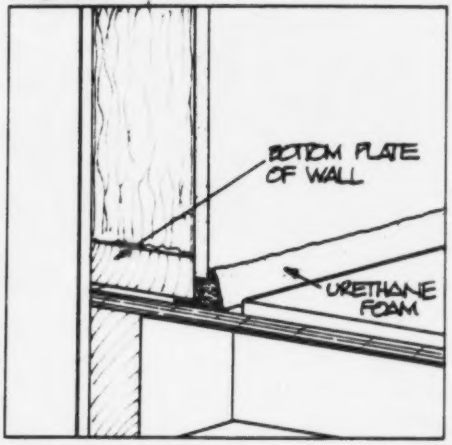
1. If the gap between the wall and the floor surface is less than 8mm wide and 8mm in depth, apply a bead of water-based acrylic sealant and tool flush with the wall surface.

2. For joints in excess of 8mm in depth, install a backer rod material in the joint, using a blunt tool. Ensure the backer rod diameter is 25% larger than the joint to be sealed and is installed to a depth of 8mm.

3. For particularly large gaps, two beads of sealant can be installed - one at the bottom plate/floor joint, and the second at the bottom plate/wall joint.

PROCEDURE 2 (continued)
SEALING THE BOTTOM PLATE BEHIND THE BASEBOARD

FIGURE 10.7


BOTTOM PLATE
OF WALL
URETHANE
FOAM

4. Re-install baseboards and nail firmly into position using finishing nails.

Procedure 3

SEALING ELECTRICAL RECEPTACLES

TOOLS

- Screwdriver
- Putty knife

MATERIALS

- CSA approved gaskets for installing behind receptacle cover plates
- Jointing cement or latex wood filler, as required
- Plastic child-safety plugs

This Procedure outlines the techniques for installing gaskets and child-safety plugs to seal air leakage openings in electrical receptacles.

The gaskets are installed behind the receptacle cover plates, and must be CSA approved for this application. Note that some available gaskets are not CSA approved; these should be avoided.

The child-safety plugs are a childproof plastic insert, which can be pushed into electrical sockets. This is a safeguard for children, but it is also useful in sealing off one type of air leakage opening in the outlet.

PREPARATION:

1. Switch off all electrical supplies to the receptacles in exterior walls.

2. Remove cover plates from switches and outlets.

3. Repair surface around receptacles to provide a smooth base for the gasket. Use jointing cement or wood filler as required.

APPLICATION:

1. Place gasket on the face of the receptacle. No special attachment procedure is required.

2. Re-install the receptacle cover plates.

PROCEDURE 3 (continued)

SEALING ELECTRICAL RECEPTACLES

3. Insert childproof plugs in little-used outlets.

4. Switch the electrical supply back on.

Procedure 4

SEALING DRYWALL/PLASTER CRACKS AND GAPS

TOOLS

- Sharp knife
- Hammer
- Pry bar
- Drywall tools
- Caulking gun

MATERIALS

- Sealant: water based acrylic (coloured to match if necessary)
- Drywall supplies
- Soap and Water
- Clean white rags

This Procedure outlines the techniques for sealing exterior wall surface cracks and joints, in the specific case of plaster and drywall finishes.

Note that, except at corners, cracks along the joints between drywall panels need not be sealed if there is a vapour barrier installed behind the gap.

PREPARATION:

1. If corner moulding is present where the exterior wall meets other walls and/or the ceiling, remove a section. If necessary, score the paint beforehand, using a sharp knife, in order to prevent paint from peeling or chipping. Determine whether the surface behind the moulding is significantly cracked or if it was left open during original construction (see Figure 10.8). If either, remove the remaining moulding (at exterior walls only).

2. For these cracks and/or gaps, and for cracks at any corners without moulding, clean the surfaces with soap and a damp cloth, and wipe dry.

3. For cracks other than those at corners, use a sharp tool to open up the crack into a small 'V'-shaped indentation.

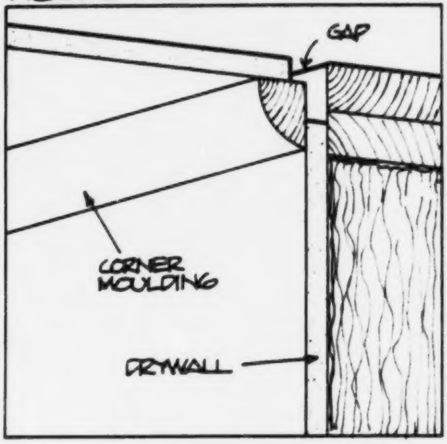
APPLICATION:

1. In the case of a large gap in a corner, fill, tape, and sand the gap using standard drywall procedures.

PROCEDURE 4 (continued)

SEALING DRYWALL/PLASTER CRACKS AND GAPS

FIGURE 10.8



2. In the case of small corner gaps or cracks, work a bead of sealant into the gap/crack.

3. In the case of cracks on the flat surface of the wall, fill the 'V' indentation with jointing cement. Sand and complete the repair using standard drywall techniques.

4. Replace any moulding, if the homeowner so desires.

Procedure 5

SEALING GAPS BETWEEN FLOORBOARDS

TOOLS

- Wire brush
- Drill and coring bit
- Hammer
- Caulking gun
- Knife
- Prybar
- Vacuum cleaner

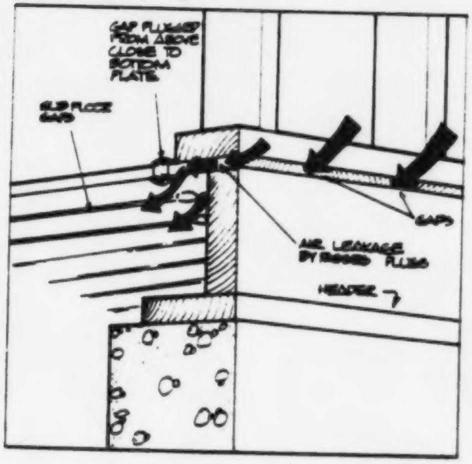
MATERIALS

- Sealant: silicone and water-based acrylic
- Corrugated fasteners (to size)
- MEK (methyl ethyl ketone)
- Clean white rags

This Procedure outlines techniques for sealing gaps between the floorboards or plywood sheets of a subfloor, when these gaps act as air leakage points. The general technique is to introduce some blockage into the crack or joint, close to the edge of the bottom plate of the wall. Different specific techniques apply to floorboard and plywood subfloors.

In the case of floorboards, the techniques presented should **only be applied if there is access to the underside of the subfloor**. This will rarely be available, except for the case of the main floor over an unfinished basement. (Where there is no access, Application step 4 below is impossible. Consequently, the plug inserted from above would be bypassed, as shown in Figure 10.9, rendering the seal ineffective.)

FIGURE 10.9


GAP PLUGGED FROM ABOVE CLOSE TO BOTTOM PLATE
SUBFLOOR GAPS
GAPS
AIR LEAKAGE BYPASSED PLUGS
HEADER

In the case of plywood (or particle board) subfloor, the technique presented will be reasonably effective in most cases, even without access to the underside of the subfloor (since the joints between the sheets are over floor joists, which help cut down air leakage).

The steps outlined in this Procedure should be undertaken in conjunction with the work outlined in Procedures 1 or 2 of this Worksheet and Procedures 1 or 2 of Foundations: Worksheet 2.

PREPARATION:

1. It is best to remove the baseboards from along those walls where the floorboards are to be sealed. If this has not already been done as a part of Procedure 2 of this Worksheet, a knife can be used to score the paint along the baseboard/wall joint. The baseboards can then be removed with a prybar.

PROCEDURE 5 (continued)

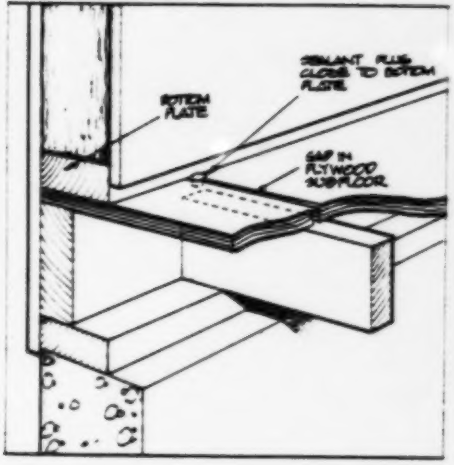
SEALING GAPS BETWEEN FLOORBOARDS

2. In the case of plywood subfloor, brush or vacuum dirt out of the gap in the subfloor, as close as possible to the point where it adjoins the bottom plate. Wipe the gap with MEK.

3. In the case of a board subfloor (tongue and groove, lapped, or square-edge), clean the floorboard gap near where it meets the bottom plate of the wall. Use a wire brush or a vacuum cleaner if necessary, then wipe the area with MEK. Next, working from below, use the same techniques to prepare the underside of the subfloor gaps, where sealant is to be applied.

Note: In the case of the plug technique described below, preparatory step 3 above should be delayed until after the required hole drilling is complete.

FIGURE 10.10



APPLICATION: Plywood subfloor technique

1. Work a plug of water-based acrylic sealant into the gap between the plywood sheets, as close to the bottom plate as possible (see Figure 10.10).

2. If the baseboard area sealing work outlined in Procedure 2 of this Worksheet has been completed, replace the baseboards.

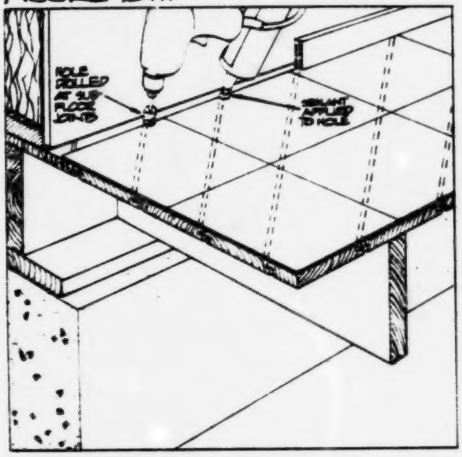
APPLICATION: Board subfloor/plug technique

1. In the case of tongue and groove or lapped boards, choose a coring drill bit that will cover the full width of the floorboard gap (typically 12mm to 18mm). Drill through each floorboard gap at a point as close to the bottom plate as possible. The regular hole will allow an effective plug of sealant to be installed. Note that square edge boards may not require drilling, if the gap has been well cleaned.

PROCEDURE 5 (continued)

SEALING GAPS BETWEEN FLOORBOARDS

FIGURE 10.11



2. Fill the cored hole with a plug of silicone sealant to make a good break in the floorboard gaps. See Figure 10.11.

3. From above, run a bead of water-based acrylic sealant along the floorboard gap, from the plug to the bottom plate.

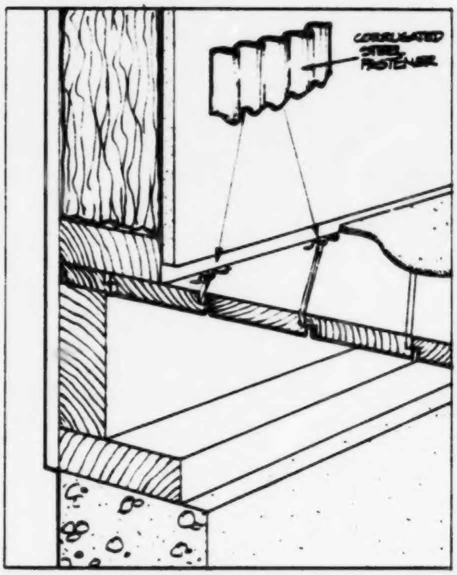
4. Do the same from below, running from the plug to the floor header.

5. If the baseboard area sealing work outlined in Procedure 2 of this Worksheet has been completed, replace the baseboards.

APPLICATION: Board subfloor/fastener technique

1. Select a corrugated fastener that is wide enough to bridge the floorboard gap and deep enough to penetrate through the floorboards.

FIGURE 10.12



2. Drive the fasteners into the floorboards, so that they bridge the gaps as close to the bottom plate as possible. This can be done with a hammer or a suitable fastener gun. The top of the fastener should be flush with the top face of the floorboards, as shown in Figure 10.12.

3. Run a bead of water-based arcylic sealant along the floorboard gap, from the fastener to the bottom plate.

4. Do the same from below, running from the fastner to the floor header.

5. If the baseboard area sealing work outlined in Procedure 2 of this Worksheet has been completed, replace the baseboards.

Worksheet 2:
Overview of indirect sealing of exterior walls

INTRODUCTION AND DISCUSSION

This Worksheet first expands upon the description of indirect leakage presented in the Introduction to this Chapter, and second considers the available indirect sealing options. Unlike most Worksheets in this Manual, no specific procedures are presented.

Indirect leakage
(Refer back to Figure 10.2)

Although most of the inside surface of exterior walls is accessible, there are several inaccessible points. These include:

- The vertical bands where partition walls join the exterior frame
- The horizontal bands where enclosed floor structures break into the exterior frame
- Exterior wall areas concealed behind special features such as bath-tubs.

These inaccessible areas cannot be readily sealed. Hence, air movement from the exterior wall into the partition walls and the floor structures - to dwell on the most important problems - is to be expected (as is air movement in the opposite direction). These partition walls and intermediate floors, in turn, contain a wide range of air leakage openings at various points around the house, including:

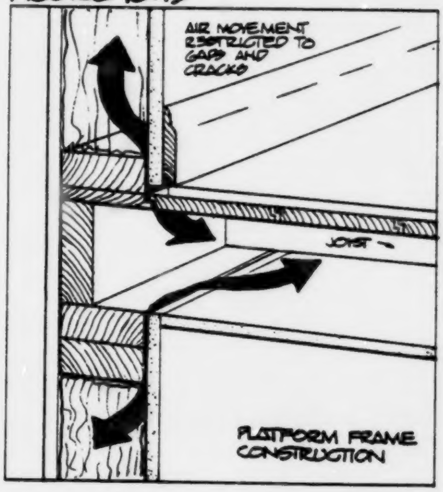
- Electrical receptacles in partition walls and intermediate ceilings

- Gaps between drywall and doors on partition walls
- Gaps at the bottom plates of partition walls
- Drywall cracks and gaps at the tops of partition walls and elsewhere
- Gaps between floorboards in the sub-floors
- Gaps around electrical services, plumbing, vents, ducts, and chimneys, where they penetrate intermediate floors
- Etc.

In short, there are many air leakage openings at various points around the house interior. In themselves they are not important, but when they are connected through the partition walls and immediate floor structures to the exterior walls, they become part of the air leakage heat loss processes of the house.

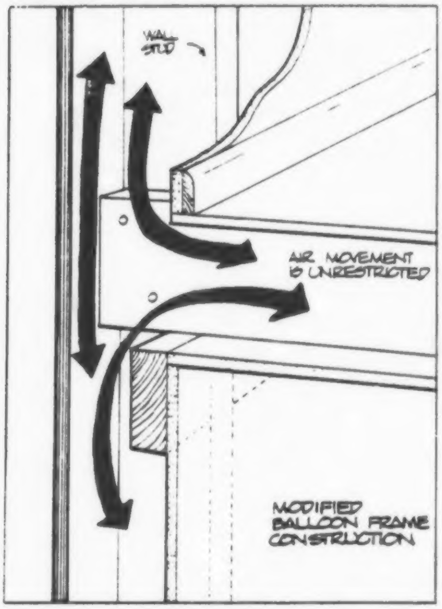
These indirect air leakage processes are particularly strong in houses with balloon frame construction. This is due to the way in which the floor joists are set into the exterior walls. In platform frame construction each wall section is effectively closed off by top and bottom plates (as shown in Figure 10.13). Thus, the air movement between the floor joist cavity and the wall cavity is fairly small. But in balloon frame construction there are large open spaces connecting the floor joist cavities to the exterior walls. The problem is not too great if the balloon frame is constructed according to current practices, with firestops that separate the various wall sections

FIGURE 10.13


AIR MOVEMENT RESTRICTED TO GAPS AND CRACKS
JOIST
PLATFORM FRAME CONSTRUCTION

and floor cavities. But in older houses there are many modified forms of balloon framing, some of which have minimal firestops and good connections between the various framing cavities, as shown in Figure 10.14.

FIGURE 10.14


WALL STUD
AIR MOVEMENT IS UNRESTRICTED
MODIFIED BALLOON FRAME CONSTRUCTION

Indirect sealing

All indirect air leakage channels can be said to have two ends: an inner end, somewhere in the house interior, and an outer end, terminating at the exterior wall envelope. Thorough indirect sealing techniques therefore require the sealing of either:

- All leakage connections where partition walls, intermediate floors, etc. join the exterior walls, or
- All interior air leakage points.

The important characteristics of these alternative approaches include the following:

- Sealing all leakage connections where partition walls and intermediate floors join the exterior walls can be quite effective if done properly. However, the job requires access to the inside of the walls and floors in question. This can be achieved only be damaging the existing wall, ceiling and floor surfaces close to the exterior walls. This leads to a large increase in the cost of the sealing work, and requires special sealing techniques
- Sealing all interior air leakage points involves the sealing of sills, electrical receptacles, gaps around door frames, etc. **on all partition walls.** It also includes sealing of electrical receptacles in **all intermediate ceilings,** and sealing of floorboard joints in **all intermediate floors.** Basically, this option means that the partition walls, intermediate floors, and

intermediate ceilings have to be treated as parts of the house envelope. This would require that they be sealed **using generally the same techniques as noted in Worksheet 1 of this chapter**.

The advantage of this option is that all the areas to be sealed are relatively accessible - though perhaps requiring the removal of casing around partition wall doors, and the removal of baseboards around partition walls. The disadvantages are that the air sealing achieved with this option is not totally effective, since there are several air leakage gaps that cannot be reached. These include plumbing, electrical services, heating ducts, etc., which are routed inside partition walls and pass through the intermediate floors. These cannot be sealed properly without incurring some structural damage. Furthermore, one of the sources of heat loss in a house is the flow of air through an intermediate floor cavity. The air infiltrates through the house envelope on one side of the house, flows along the floor joist cavities, and exists through the house envelope on the opposite side of the house. The described sealing option does nothing to stop this process.

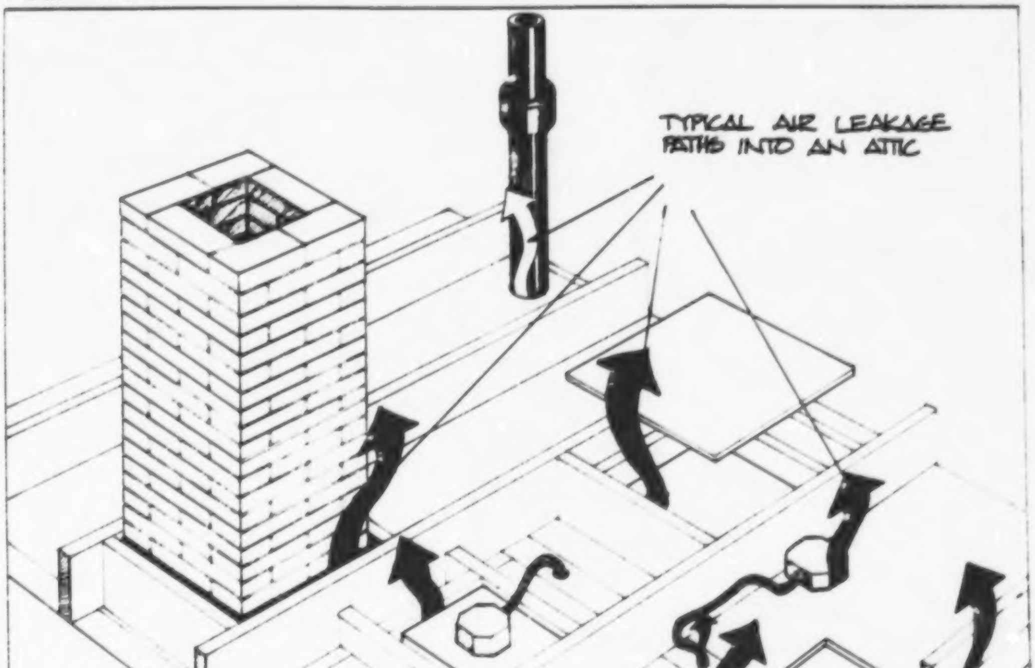
In summary, the sealing of indirect air leakage points, when based on accessible points, involves a large increase in the cost and extent of the sealing work, and is not totally effective in eliminating the air leakage through the exterior walls.

The sealing of indirect air leakage points, when concentrated on partition walls and floors where they intersect the house envelope, gives a highly effective seal if done properly. But this approach involves damage to the existing house surfaces, and requires refined sealing techniques. These raise the costs of the sealing work by a large amount.

In view of these conclusions, specific indirect sealing procedures are not presented in this edition of this Manual. In some circumstances, contractors **may** find it advantageous to seal some major leakage points in partition walls and intermediate floors, using techniques such as those presented elsewhere in this Manual. See Chapter 5 for further guidance.

Chapter 11:
Attics and Roof Spaces

FIGURE 11.1


TYPICAL AIR LEAKAGE PATHS INTO AN ATTIC

INTRODUCTION

In practically all houses, the ceilings above any heated space contain a large number of air leakage openings, including:

- Gaps at the top of partition walls
- Gaps at the top of exterior walls
- Various holes through and around electrical receptacles
- Holes around electrical cables
- Gaps around vent pipes and plumbing stacks
- Gaps around chimneys
- Gaps around heating duct runs that penetrate the ceiling
- Gaps around the attic hatch.

Figure 11.1 illustrates a number of these air leakage paths. Note that, for clarity, no insulation is shown in the diagram. In fact, most attics/roof spaces do have at least some insulation - but this insulation does little to block air leakage. Even the older types of insulation with attached vapour barriers do not control air leakage - there are simply too many breaks in the barrier. If a continuous vapour barrier (of polyethylene, for instance) is present, air leakage might be greatly reduced, particularily if special effort has been taken to seal any breaks in the barrier. Unfortunately, except in some newer houses, such a continuous seal is rare.

The result: in total, the air leakage points described above often represent a very large leakage area. In some cases, it has been estimated that these gaps contribute about 30% of the total air leakage area of the house. Accordingly, except for those houses with an excellent vapour barrier (and those which have already been sealed), air sealing the attic/roof space can produce significant savings.

Exfiltration effects

Because of the stack effect (see Chapter 2), the air leakage through ceilings consists predominantly of outward flow, ie., exfiltration. Apart from the heat losses that arise from exfiltration, this process is important because it carries humid house air into the attic or roof space.

In a properly functioning attic or roof space, the humid air is removed by ventilation as fast as it exfiltrates through the ceiling. As a result, a good attic or roof space should display no signs of moisture damage due to exfiltration. However, contractors will encounter many houses where exfiltration has led to condensation and moisture damage. This may be due to excessive exfiltration or inadequate ventilation, or a combination of the two.

In some houses the moisture damage may have been triggered by the recent addition of more ceiling insulation. This tends to bring about moisture damage in two ways. First, if carelessly installed, the extra insulation may block the ventilation air flow through the roof eaves. The reduced ventilation rate then results in a higher moisture concentration in the attic or roof space. Secondly, the extra insulation should cause the attic or roof space to operate at a colder temperature, which tends to accelerate the processes of condensation and frost build-up in the attic.

When sealing techniques are applied to the ceiling, this reduces heat losses and also reduces the risk of moisture damage in attics and roof spaces. In many instances, this will eliminate moisture damage processes that may have been going on for several years.

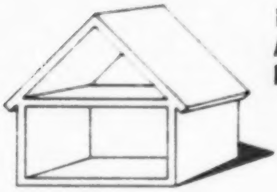
Consequently, sealing air leakage paths into an attic or roof space has a double cost benefit: it reduces energy consumption and it virtually eliminates the long-term rehabilitation costs that would be needed to repair the effects of moisture damage. This chapter outlines the recommended sealing techniques for the most important types of attic/roof space air leakage.

For definitions of specialized terminology, refer to the glossary at the end of this Manual.

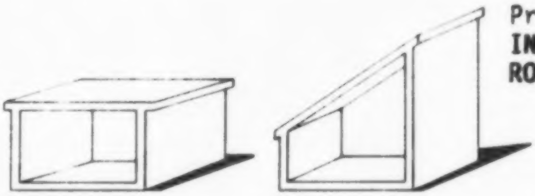
GUIDE TO THE WORKSHEETS

The majority of Canadian low-rise residences (an estimated 78%) have accessible attics or roof spaces. The remainder of the housing stock has either a half-storey roof development, or an inaccessible roof space, such as a flat roof or a cathedral ceiling.

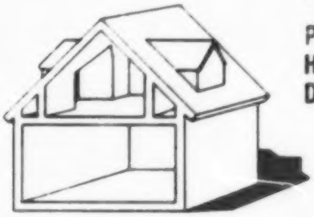
This Chapter presents step-by-step procedures for sealing each of these types of attic/roof space:



Procedures for
**ACCESSIBLE ATTICS/
ROOF SPACES** . . . . . . Worksheet 1



Procedures for
**INACCESSIBLE ATTICS/
ROOF SPACES** . . . . . . Worksheet 2

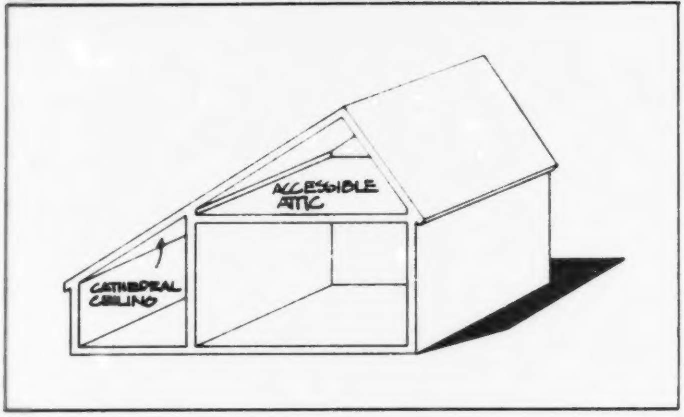


Procedures for
**HALF STOREY
DEVELOPMENTS** . . . . . . Worksheet 3

For each specific procedure described in each Worksheet, step-by-step preparation and application requirements are described. In addition, the necessary tools and materials are identified in each case.

For most houses, it will be necessary to refer to only one Worksheet. Note, however, that in some houses different parts of the house will have different types of attic/roof space, such as is shown in Figure 11.2. In such cases, the two relevant Worksheets should be referred to, in order to properly seal each part of the ceiling area.

FIGURE 11.2



Worksheet 1:
Procedures for accessible attics/roof spaces

INTRODUCTION:

In the case of accessible attics/roof spaces, it is best to conduct air-sealing work **from inside the attic/roof space.** This recommendation is based on the fact that the alternative - working from inside the house - is likely to be much less effective (unless major, expensive measures are implemented).

As was noted in the introduction to this chapter, there are many points of air leakage into the typical attic/roof space. The procedures presented in this Worksheet provides "in-attic" sealing techniques for each of the most common leakage points:

Procedure 1: Sealing the tops of partition walls.

Procedure 2: Sealing the tops of perimeter walls.

Procedure 3: Sealing around plumbing stacks.

Procedure 4: Sealing around brick chimneys.

Procedure 5: Sealing around factory-built metal chimneys.

Procedure 6: Sealing around electrical receptacles.

INTRODUCTION (continued)

Procedure 7: Sealing around electrical cables passing into the attic/roof space.

Procedure 8: Sealing around ducts passing into the attic/roof space.

Procedure 9: Sealing the attic hatch.

In order to thoroughly seal the attic/roof space of any given house, a contractor should examine each of the leakage points covered by these 9 procedures. Some of the problem areas will not be present in some houses (for instance, some houses have no chimneys). Other potential problem areas may not need sealing (for instance, many houses have plumbing stacks that are sealed with oakum). However, **most houses with accessible attics are likely to require sealing at most of the points dealt with by Procedures 1-9** (subject to the guidance presented in Chapter 5 of this Manual).

Procedure 1

SEALING THE TOPS OF PARTITION WALLS

TOOLS

- Small brush or whisk broom
- Caulking gun or foam dispensing equipment, as required
- Saw
- Hammer

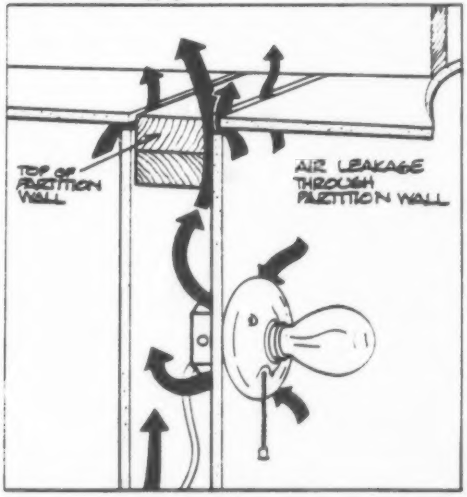
MATERIALS

- Clean white rags
- MEK (methyl ethyl ketone)
- Sealant: silicone or acoustical
- Urethane foam, if required
- Plywood, as required
- Nails
- Backing material, if required

This Procedure provides techniques for sealing joints at the top of interior partition walls. These joints can be a source of air leakage from the rooms below, both directly (through corner cracks in the interior finish) and indirectly (via innumberable leakage paths into the partition wall and up to the attic).

Figure 11.3 illustrates a typical situation. Figure 11.4 illustrates a less common situation, where the interior partition walls have no top plates. Because of these construction variations, three application techniques are presented: one for the typical situation and two alternatives for walls with no top plates.

FIGURE 11.3



PREPARATION:

1. Identify the location of the partition walls from a map prepared of the floor below.

2. Remove or brush aside the attic insulation from above the walls.

3. Use a small brush or whisk broom to clear all cracks of insulation and debris.

4. Clean surfaces to be sealed by wiping with MEK.

APPLICATION: Partitions with top plates

1. Apply a uniform and continous bead of silicone or acoustical sealant along the entire length of the partition wall on either side of the top plate, as shown in Figure 11.5.

2. Figure 11.6 shows variations of sealing techniques that may be necessary if the top plate of the wall is close to the ceiling truss or joist.

3. Where two partition walls meet with one running parallel to the trusses/joists and the other running perpendicular, combinations of the above

FIGURE 11.4

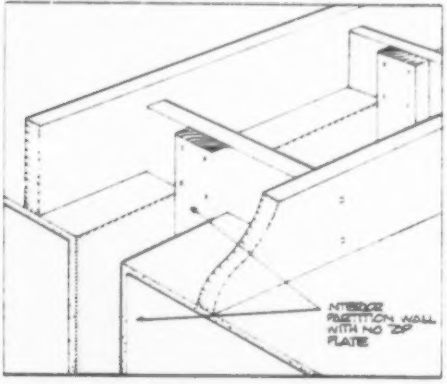

INTERIOR
PARTITION WALL
WITH NO TOP
PLATE

FIGURE 11.5A

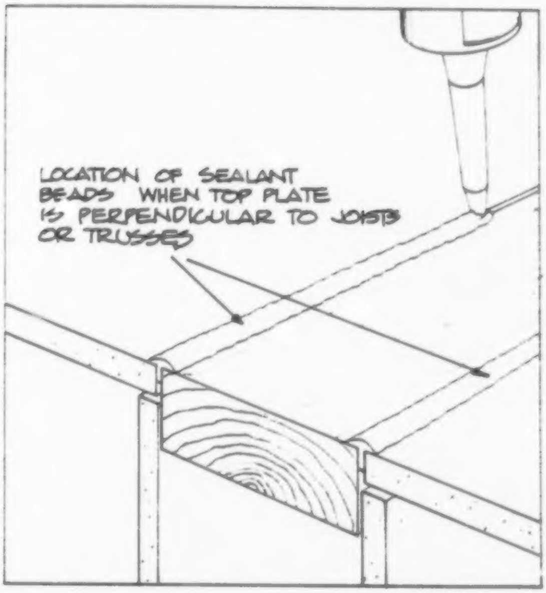

LOCATION OF SEALANT
BEADS WHEN TOP PLATE
IS PERPENDICULAR TO JOISTS
OR TRUSSES

FIGURE 11.5B

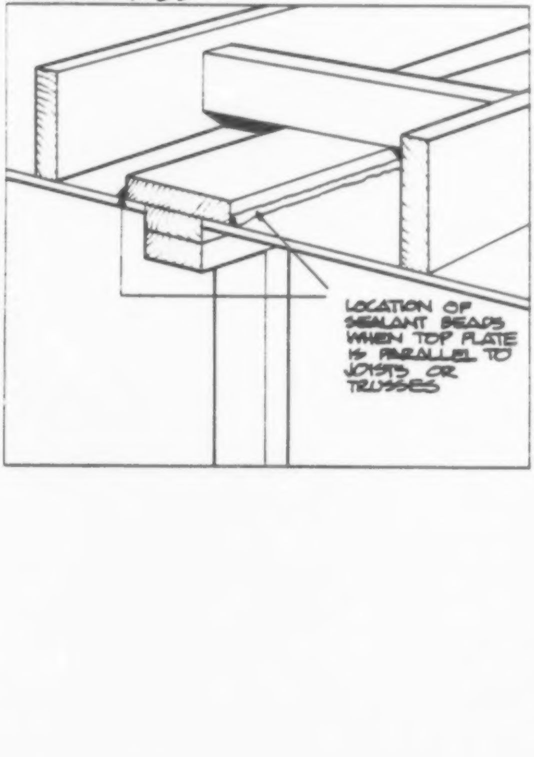
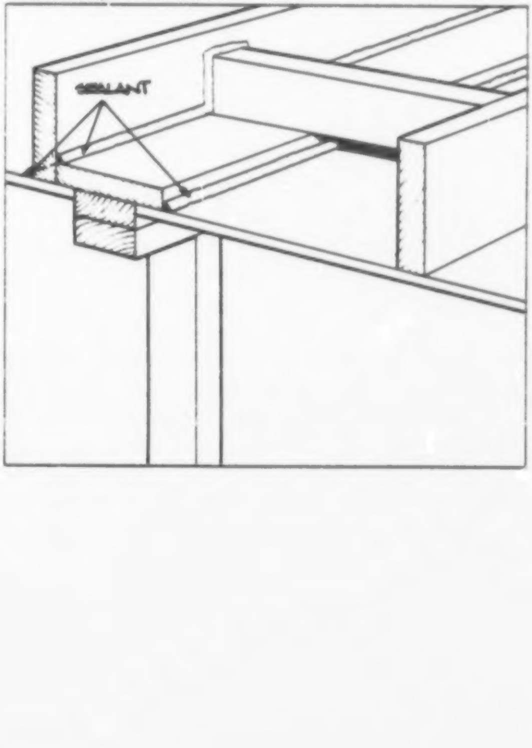

LOCATION OF
SEALANT BEADS
WHEN TOP PLATE
IS PARALLEL TO
JOISTS OR
TRUSSES

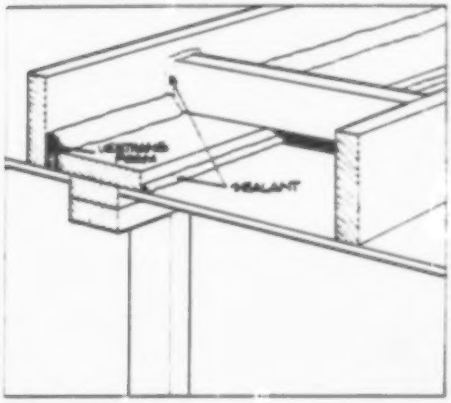
FIGURE 11.6A



PROCEDURE 1 (continued)

SEALING THE TOPS OF PARTITION WALLS

FIGURE 11.6 B



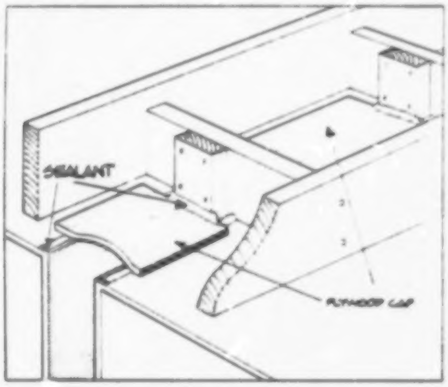
techniques should be used, as required, to seal at the joint.

4. Replace the original insulation.

APPLICATION: Walls with no top plates (plywood technique) (See Figure 11.7)

1. Inspect the opening at the top of the wall. If the working surface of the ceiling is smooth and there is adequate work space, this plywood sealing technique can be used. It is effective for partition walls that run either parallel or perpendicular to the trusses/joists.

FIGURE 11.7



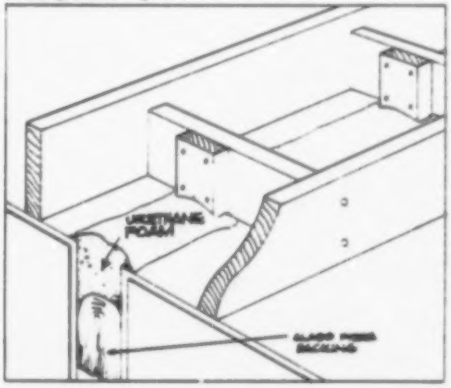
2. Cut a piece of plywood to fit over the wall cavity, sized as required. Leave a notch for any electrical wiring that passes through the top of the partition wall.

3. Apply a bead of silicone sealant along the ceiling on each side of the wall cavity.

4. Press and nail the plywood into place and apply further sealant at any gaps around the edges of the plywood. Seal the notch as outlined in Procedure 7 of this Worksheet.

5. Replace the original insulation.

FIGURE 11.8



APPLICATION: Walls with no top plates (foam technique) (See Figure 11.8)

1. Inspect the opening at the top of the wall. This foam technique can be used when the working space is confined and when the surface of the ceiling is irregular (for instance, lath with lumps of plaster sticking through). Note: this technique has not yet been thoroughly evaluated.

2. Install a backing in the cavity between each pair of partition wall studs. This backing should be positioned so that there is a space of about 100mm above it. Backing materials can be glass

PROCEDURE 1 (continued)

SEALING THE TOPS OF PARTITION WALLS

fibre batts, rigid insulation, plywood, etc. - anything that will give reasonable support to urethane foam during installation.

3. Fill the exposed section of the cavity with fast-cure urethane foam, making sure that it makes a good sealing contact with the ceiling on each side, and with the partition wall studs. Be sure to allow for the expansion of the foam.

4. Replace the original insulation.

Procedure 2

SEALING THE TOPS OF PERIMETER WALLS

TOOLS

- Small brush or whisk broom
- Caulking gun
- Vacuum cleaner

MATERIALS

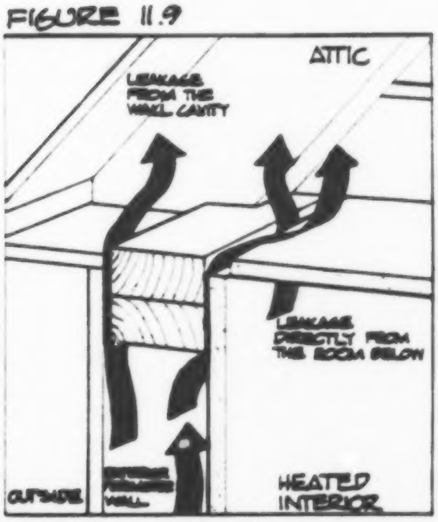
- Clean white rags
- MEK (methyl ethyl ketone) or methyl alcohol
- Sealant: silicone, acoustical, and/or urethane foam (one or two part)

This Procedure outlines techniques for sealing joints at the top of exterior walls, working from the attic/roof space.

Figure 11.9 illustrates the air leakage paths that can, potentially, be sealed. Note, however, that the top plates of exterior walls are actually outside the sealed "envelope" of the house.

Therefore, air moving in the wall (like air in the attic) can be considered to be outside air. In principle, there is not a great deal to be gained by attempting to prevent the movement of outside air from one spot to another (i.e. from the wall cavity to the attic). Furthermore, if there is any moisture movement into the exterior walls of the house, air movement up the walls and into the ventilated attic or roof space has the beneficial effect of helping to prevent moisture accumulation problems in the wall. Completely sealing the top of the perimeter wall would eliminate this advantageous process.

FIGURE 11.9


ATTIC
LEAKAGE FROM THE WALL CAVITY
LEAKAGE DIRECTLY FROM THE ROOM BELOW
OUTSIDE
WALL
HEATED INTERIOR

On the other hand, it is usually difficult to achieve a good seal on the inner face of exterior walls, as discussed in Chapter 10. Sealing the tops of the exterior walls can, to some degree, compensate for this limitation. Furthermore, the top of the exterior wall can also be a source of air leakage directly from the heated room below, as shown in Figure 11.9. These considerations support the sealing of the tops of perimeter walls.

Taking account of these various factors, this Manual recommends that **only the inner side of the exterior wall top plate be sealed.** Furthermore, **when the exterior walls have no vapour barrier, and when there is risk of moisture build-up in the exterior walls for any other reason, it is not advisable to conduct the sealing work described below.**

PROCEDURE 2 (continued)

SEALING THE TOPS OF PERIMETER WALLS

FIGURE 11.10 A

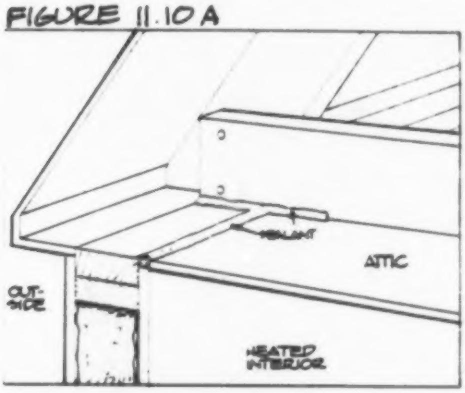
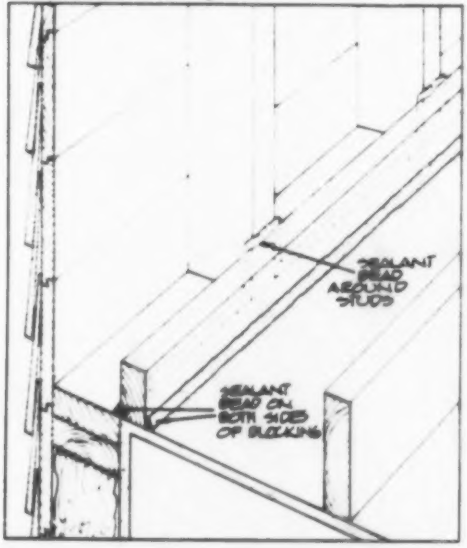


FIGURE 11.10 B


SEALANT BEAD AROUND STUDS
SEALANT BEAD ON BOTH SIDES OF BLOCKING

PREPARATION:

1. Remove batt insulation or loose fill insulation material from the areas to be sealed.

2. Use a small brush or whisk broom to remove all dirt and debris from the cracks or joints to be sealed. Use a vacuum cleaner if convenient and necessary.

3. Clean the joint and surrounding surfaces with MEK.

APPLICATION:

1. In cases where the working area is not too confining, apply a uniform and continous bead of silicone or acoustical sealant to all cracks and joints at the inner side of the perimeter wall top plate, as shown in Figure 11.10a.

2. Where the working space is too confined to carry out Step 1, an alternative is to apply a uniform and continous covering of a one or two-part urethane foam sealant to the top of perimeter walls. To the degree possible, attempt to seal gaps on the inner side of the top plate (leaving those on the outer side uncovered).

3. Sometimes, unusual situations will be encountered at the gable end wall, such as that illustrated Figure 11.10b where the gap between the top plate and the interior finish is concealed. In such cases, apply a uniform and continuous bead of silicone or acoustical sealant to all cracks and joints on either side of the blocking, including around the wall studs.

4. Replace insulation materials. Be sure to leave adequate clearance between the insulation and the roof surface, in order to allow adequate ventilation from soffits.

Procedure 3

SEALING AROUND PLUMBING STACKS

TOOLS

- Caulking gun
- Staple gun
- Paper stapler
- Wire brush
- Blunt tool
- Knife or scissors

MATERIALS

- Oakum
- 0.150mm Polyethylene sheet
- Sealant: acoustical
- MEK (methyl ethyl ketone)
- Clean white rags
- Duct tape
- Staples

This Procedure outlines techniques for sealing around plumbing stacks. Two techniques are presented, the choice being determined principally by the size of the gap around the stack. Both options are designed to give a reasonably tight seal, while allowing the stack to move upwards and downwards under the effects of thermal expansion.

Note that, in some regions, it is standard practice in new construction to seal around plumbing stacks with oakum or other packing materal. In many such houses, therefore, no further sealing will be required, if the original seal appears to be adequate. Note that insulation in the gap does not provide an adequate seal.

PREPARATION:

1. A house may have several plumbing stacks; identify the location of each.

2. If there is no adequate seal around any or all of the stacks, remove insulation and debris from around the stack.

3. If the polyethylene technique is to be used, clean the working surface around the stack with a wire brush, MEK, and rags. Similarly, clean a band around the plumbing stack itself, where the polyethylene is to be applied.

APPLICATION: Oakum technique

1. Inspect the gap around the stack. This technique may be used only in those cases where the stack passes through the top plates of a plumbing wall, and then only if there is a fairly regular gap of less than 18mm around the stack.

PROCEDURE 3 (continued)

SEALING AROUND PLUMBING STACKS

---

2. Work oakum into the gap and compress it as tightly as possible using a blunt tool.

3. Replace the original insulation.

APPLICATION: Polyethylene technique
(See Figure 11.11)

1. Inspect the gap around the stack. This technique should be used where the oakum technique is unsuitable because:

- the gap around the stack exceeds 18mm; or
- the gap is irregular; or
- the gap is too small to allow insertion of oakum; or
- the stack comes directly through the ceiling finish and there is no surrounding wood frame in which to compress oakum.

2. Cut a strip of 0.150mm polyethylene 300mm wide and long enough to wrap around the stack with a good overlap.

3. Apply a bead of acoustical sealant around the stack, where the polyethylene is to be sealed. Position the bead so that, when the installation is complete, the polyethylene shroud will have considerable loose material. This is necessary to allow for vertical movement of the stack due to expansion and contraction. As much as 25mm of movement must be allowed for.

4. Wrap the polyethylene around the stack and pull tight to make good contact with the sealant.

5. Wrap several turns of duct tape around the stack so that it covers the bead of sealant, the top edge of the polyethylene, and the adjacent stack surface.

6. Apply acoustical sealant between the two layers of polyethylene at the vertical overlapping seam. Secure this joint with a standard paper stapler.

PROCEDURE 3 (continued)

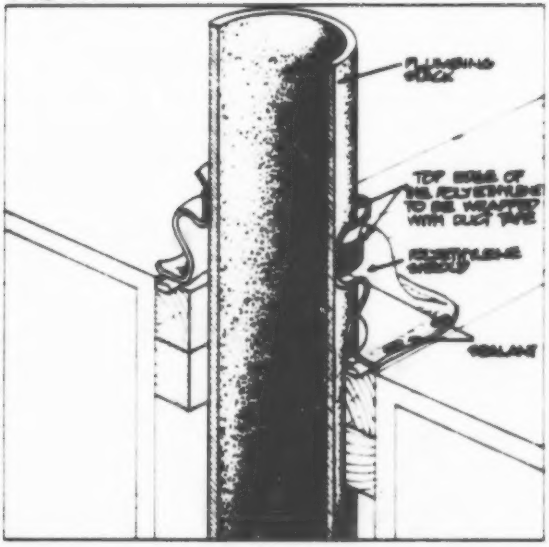
SEALING AROUND PLUMBING STACKS

7. Apply a bead of acoustical sealant on the top plate or ceiling surface around the stack.

8. Press the bottom of the polyethylene shroud into the sealant to make a good seal all around. Secure the seal by stapling through the polyethylene and bead into the top plate or ceiling.

9. Replace the original insulation.

FIGURE 11.11


PLUMBING STACK
TOP EDGE OF THE POLYETHYLENE TO BE WRAPPED WITH DUCT TAPE
POLYETHYLENE SHROUD
SEALANT

Procedure 4

SEALING AROUND BRICK CHIMNEYS

This Procedure provides a technique for sealing around most brick chimneys, where they pass through the ceiling. However, note that this technique should only be used on chimneys that conform to good building practice.

Specifically, the National Building Code (NBC) sets as a guideline a minimum 50mm space between the outside surface of any chimney and the nearest combustible surface. Contractors finding construction not meeting this guideline should not proceed with any sealing around the chimney (until the problem has been corrected), since this might increase the fire danger.

Note that gypsum board is considered to be combustible when applied near chimneys (as are most types of insulation, most sealants, and most vapour barriers).

PREPARATION:

1. Remove all insulation from around the chimney and inspect the structure. The chimney should have a continuous wood frame running around it, as shown in Figure 11.12. In some cases the gap between the chimney and wood frame may be filled with combustible material or may be less that 50mm; in such cases, do not proceed with any sealing around the chimney (as noted above). In other cases, the gap may be adequately sealed with non-combustible material. If so, Application steps 4 and 5 (below) should still be followed, but steps 1-3 are unnecessary. Note that insulation in the gap cannot be considered to provide an adequate seal.

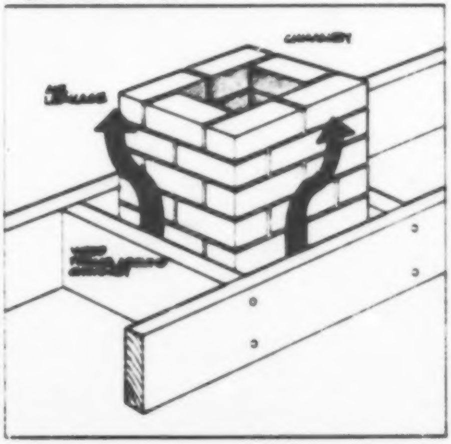
TOOLS

- Brush
- Hammer
- Caulking gun
- Metal cutters
- Putty knife

MATERIALS

- Sealant: silicone and acoustical
- Muffler cement or other non-combustible sealant
- MEK (methyl ethyl ketone)
- Clean white rags
- Nails
- Thin galvanized metal sheet

FIGURE 11.12



PROCEDURE 4 (continued)

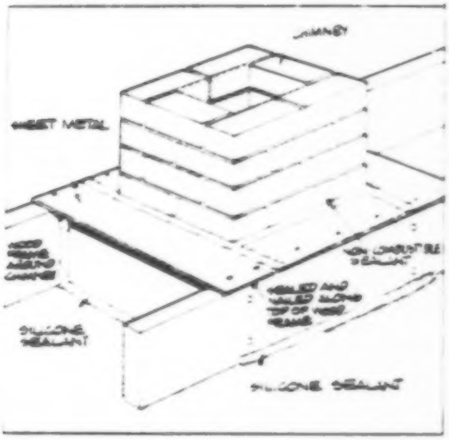
SEALING AROUND BRICK CHIMNEYS

2. Where the gap around the chimney is 50mm or more and requires sealing, use a brush to remove dust and debris from the working area.

3. Clean all surfaces to which sealant will be applied using rags and MEK.

APPLICATION:

FIGURE 11.13


CHIMNEY
SHEET METAL
WOOD FRAME AROUND CHIMNEY
NON-COMBUSTIBLE SEALANT
NAILED AND SEALED ALONG TOP OF WOOD FRAME
SILICONE SEALANT
SILICONE SEALANT

1. Apply a bead of acoustical sealant along the top of the wood frame surrounding the chimney.

2. Cut strips of metal sheet to fit around the chimney, as shown in Figure 11.13. Nail (or screw) these in place on top of the sealant bead, so that they butt tightly to each other and against the chimney.

3. Apply muffler cement or another non-combustible sealant to the metal sheet joints and to the joints between the metal and the chimney. Make sure that a good seal is achieved.

4. Apply silicone sealant to the joints in the wood frame around the chimney.

5. Replace the original insulation, leaving a 50mm gap between the insulation and the chimney.

Procedure 5

SEALING AROUND FACTORY-BUILT METAL CHIMNEYS

TOOLS

- Brush
- Hammer
- Saw
- Metal cutters
- Caulking gun
- Screw driver
- Drill and bits
- Putty knife

MATERIALS

- Spruce blocking to match trusses
- Thin galvanized metal sheet
- Galvanized metal cylinder, sized as required
- Metal collar for top of cylinder
- Nails
- Self-tapping metal screws
- Long machine bolts
- Sealant: silicone or water-based acrylic
- Muffler cement or other non-combustible sealant
- Wire mesh, if required
- MEK (methyl ethyl ketone)
- Clean white rags

This Procedure outlines a technique for sealing around factory-built metal chimneys. However, before sealing such chimneys, contractors should be aware of two limitations:

- First, the technique described may contravene the certification requirements of some chimneys. Specifically, boxing-in a chimney section with firestops and applying sealant between a chimney and the surrounding firestop could affect the safe performance of certain chimneys. Therefore, before proceeding, always ensure that local codes, building material standards, and the manufacturer's instructions permit the sealing procedure described.

- Second, the National Building Code (NBC) sets as a guideline a minimum 50mm space between the outside surface of any chimney and the nearest combustible surface. Contractors finding construction that does not meet these guidelines should not proceed with any sealing around the chimney, until the problem has been corrected.

Figure 11.14 illustrates a typical installation of a factory-built metal chimney. Note that, though these chimneys are insulated, they can nevertheless get hot. Accordingly, they should have been installed with a firestop surrounding the chimney where it passes through the ceiling into the attic (though some chimneys have been improperly installed without firestops).

Firestops are normally metal sheets. They are usually poorly fitted, and so allow a large amount of air leakage, as shown in Figure 11.14. In addition, within a certain radius of the chimney, they cannot (by code) have any insulation directly on top - which results in considerable heat loss.

FIGURE 11.14

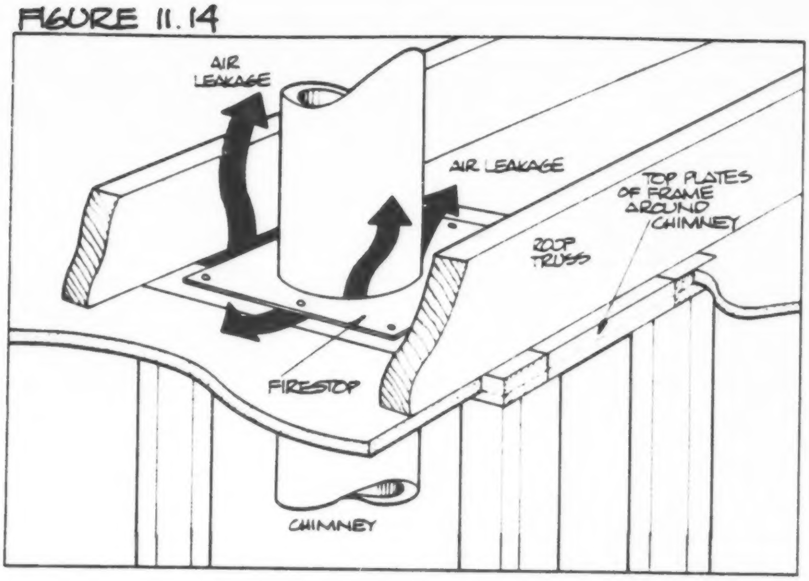

AIR LEAKAGE
AIR LEAKAGE
TOP PLATES OF FRAME AROUND CHIMNEY
ROOF TRUSS
FIRESTOP
CHIMNEY

FIGURE 11.15

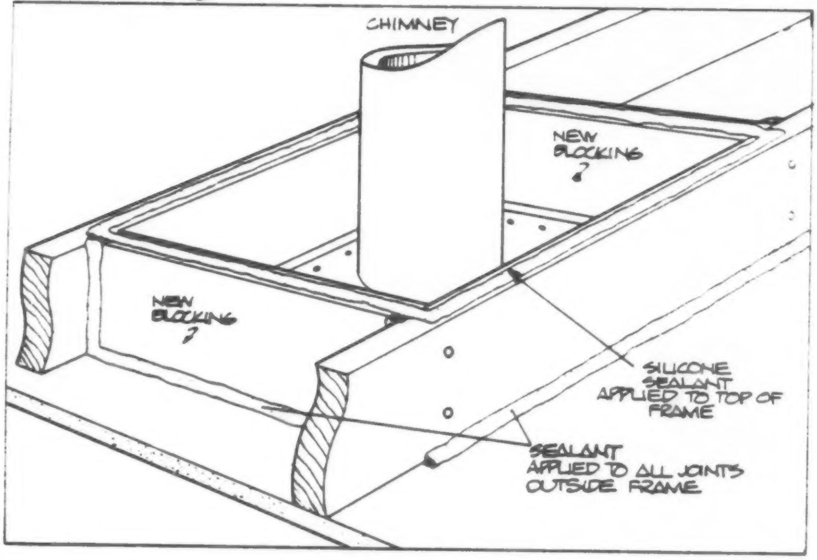
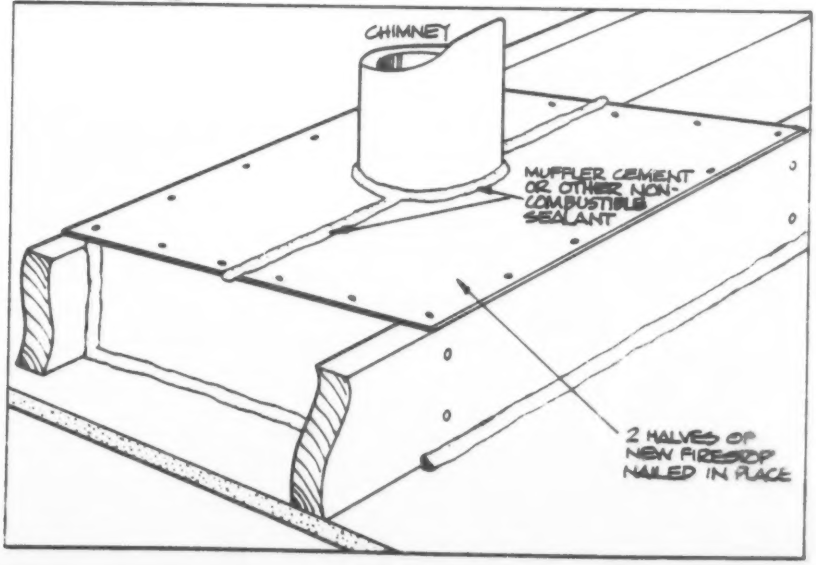

CHIMNEY
NEW BLOCKING
NEW BLOCKING
SILICONE SEALANT APPLIED TO TOP OF FRAME
SEALANT APPLIED TO ALL JOINTS OUTSIDE FRAME

FIGURE 11.16


CHIMNEY
MUFFLER CEMENT OR OTHER NON-COMBUSTIBLE SEALANT
2 HALVES OF NEW FIRESTOP NAILED IN PLACE

PROCEDURE 5 (continued)
SEALING AROUND FACTORY-BUILT METAL CHIMNEYS

This Procedure outlines a technique for installing a new, properly sealed firestop. The steps apply to the common case where the original, poorly fitted firestop is installed on the top plates of a frame around the chimney. (If the existing firestop fits well and is in good condition, it can sometimes be sealed using an adaptation of these techniques.)

In addition, this Procedure outlines steps for providing insulation in the vicinity of the firestop, while maintaining a recommended 50mm clearance between the insulation and the chimney.

PREPARATION:

1. Clear a working area by removing insulation and brushing away debris.

2. Install blocking between the roof trusses to make a tightly-fitted frame around the chimney.

3. Clear the various joints around the outside of the frame with a brush, MEK, and rags.

APPLICATION:

1. Apply water-based acrylic or silicone sealant at all joints on the outside of the frame, as shown in Figure 11.15.

2. Prepare a thin galvanized metal sheet to fit around the chimney. The sheet should be in two sections, sized to match the top of the wood frame.

3. Apply a silicone sealant bead around the top of the frame, as shown.

4. Install the new metal sheet to be a tight fit around the chimney, and nail in place on top of the sealant bead.

5. Apply muffler cement or other non-combustible sealant to the joint between the two sections of firestop and between the firestop and the chimney, as shown in Figure 11.16. Use a fine wire mesh as a backing for the sealant, if required.

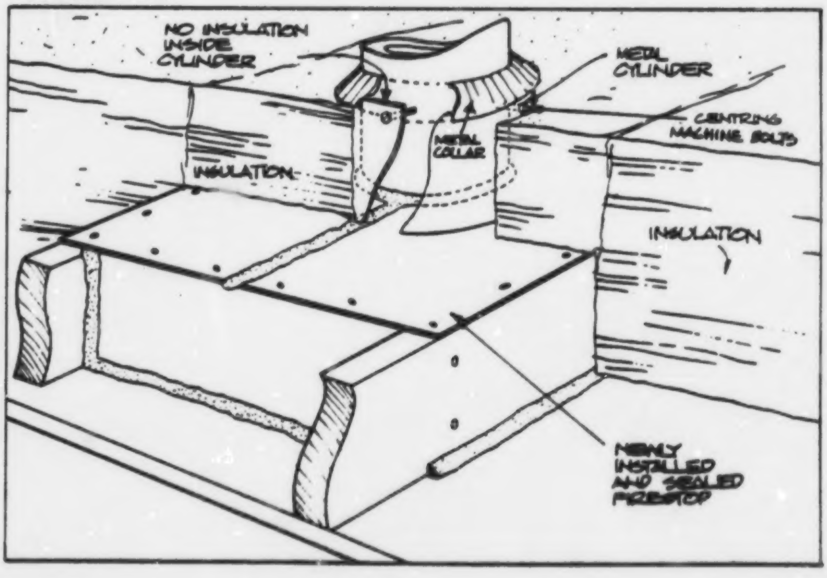
6. Obtain a custom-made cylinder of thin, rolled galvanized metal, with unjoined edges. This cylinder should have a diameter at least 100mm larger than that of the chimney, and should be at least 300mm high. Install the cylinder around the chimney, on top of the new firestop. Join the edges with self-tapping metal screws.

7. Install three or four long machine bolts through the cylinder, and adjust to centre the cylinder. The gap between the cylinder and the chimney should be 50-75mm all around, or as required by the type of chimney and type of insulation being used. The bolts must not pierce the walls of the chimney, as this will usually void the chimney certification.

8. Obtain or make a metal collar, designed to fit around the chimney. The collar should be positioned on top of the metal cylinder, covering the gap between the chimney and cylinder (so as to prevent insulation or debris from falling into the gap).

9. Replace the insulation, as shown in Figure 11.17. There can be no insulation between the chimney and the new cylinder.

FIGURE 11.17



Procedure 6

SEALING AROUND ELECTRICAL RECEPTACLES

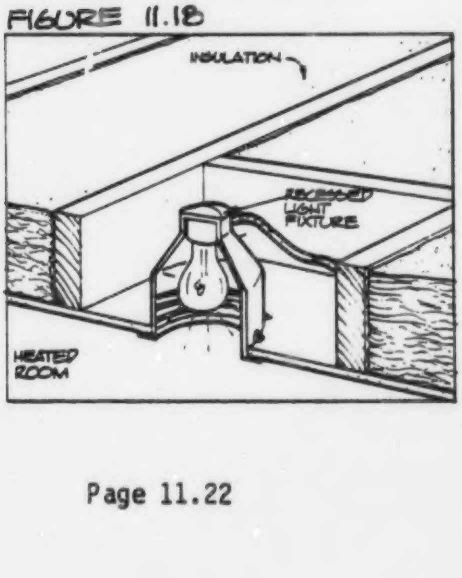
TOOLS

- Brush
- Saw
- Hammer
- Caulking gun
- Staple gun
- Paper stapler
- Utility knife or scissors

MATERIALS

- Sealant: Silicone and acoustical
- Wood blocking, as required
- 0.150 mm polyethylene sheet
- Plywood, as required
- Nails
- Duct tape
- MEK (methyl ethyl ketone) or mineral spirits
- Clean white rags

FIGURE 11.18



This Procedure outlines two alternative techniques for sealing around electrical receptacles in ceilings. The decision as to which technique to use is primarily dependent on the nature of the surface to be sealed. Contractors must be careful to observe appropriate safety precautions in this (and all) sealing work. See Chapter 6.

The techniques presented **must not be used on recessed pot lights** (see Figure 11.18). Where such pot lights are encountered it is most **strongly recommended that they be replaced by non-recessed light fixtures before proceeding**. Recessed light fixtures are a fire hazard in well insulated ceilings.

The sealing work described here provides the contractor with an opportunity to identify another potential hazard. Electrical cables have specified safe temperature limits. When a cable is buried in thermal insulation, the heat from the cable may raise its temperature to a higher than normal level. In some cables this may cause deterioration of the electrical insulation. When there are obvious signs of deterioration in electrical cables, contractors are advised to bring this to the attention of electrical inspectors before replacing thermal insulation around the cables.

PREPARATION:

1. Remove insulation to give a clear working area around the receptacle.

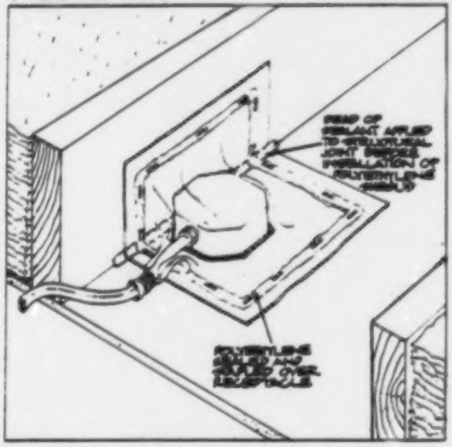
2. Using a brush, remove all loose material from the working area.

3. Clean all surfaces to which sealant will be applied using MEK or mineral spirits. (In the case of the box technique, delay this step until after the blocking has been installed). Do not apply MEK to electrical wiring.

PROCEDURE 6 (continued)

SEALING AROUND ELECTRICAL RECEPTACLES

FIGURE 11.19


BEAD OF SEALANT APPLIED TO STRUCTURAL JOINT BEFORE INSTALLATION OF POLYETHYLENE SHROUD
POLYETHYLENE SEALED AND STAPLED OVER RECEPTACLE

APPLICATION: Polyethylene technique

1. Inspect the area around the receptacle. If there are smooth working surfaces, this technique can be used.

2. Apply acoustical sealant along any structural joints that will eventually be covered by the polyethylene shroud.

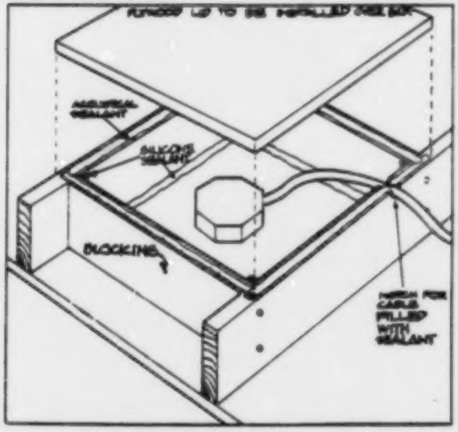
3. Cut a piece of 0.150 mm polyethylene, sized to fit around the receptacle as shown for one common situation in Figure 11.19. Slit the polyethylene to fit around any cables.

4. Fit the polyethylene around the cables and make a secure airtight joint by wrapping with several turns of duct tape. Seal the slit by overlapping the two edges, with a bead of acoustical sealant pressed in between. Secure the seam by stapling with a paper stapler.

5. Apply a continous bead of acoustical sealant around the work area, in a pattern such as that shown in Figure 11.19. Press the polyethylene to the sealant, and secure with staples.

6. Replace the original insulation.

FIGURE 11.20


PLYWOOD LID TO BE INSTALLED OVER BOX
ACOUSTICAL SEALANT
SILICONE SEALANT
BLOCKING
NOTCH FOR CABLE FILLED WITH SEALANT

APPLICATION: Box technique

1. Inspect the area around the receptacle. This technique should be used on irregular surfaces such as plaster-on-lath, where it is difficult to obtain a seal by the polyethylene technique.

2. Install blocking to make a tightly fitted wood frame around the receptacle, as shown in Figure 11.20.

PROCEDURE 6 (continued)

SEALING AROUND ELECTRICAL RECEPTACLES

3. Apply sealant bead to all joints on the inside of the frame, using silicone sealant.

4. Cut a notch in the top of the frame to accept each cable. Fill the notch with a bed of silicone sealant and set the cable in the recess.

5. Apply a continuous bead of acoustical sealant around the top of the frame. Cut a plywood lid to size, and nail in place on top of the frame.

6. Replace the insulation.

Procedure 7

SEALING AROUND ELECTRICAL CABLES PASSING INTO THE ATTIC/ROOF SPACE

TOOLS

- Caulking gun
- Brush

MATERIALS

- Sealant: silicone
- Oakum, if required
- Mineral spirits
- Clean white rags

This Procedure outlines techniques for sealing around electrical cables when they pass through the top of partition walls.

PREPARATION:

1. Locate the position of each electrical cable.

2. Clear away the insulation and debris around the penetration. Brush clean and wipe with mineral spirits.

APPLICATION:

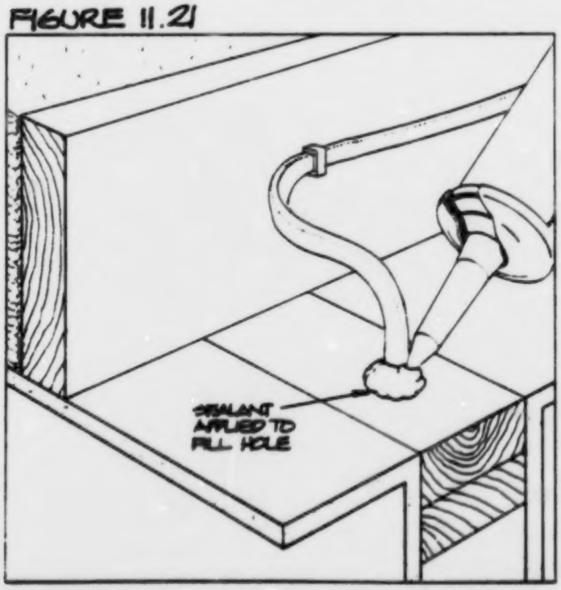
(See Figure 11.21)

1. Work silicone sealant into the hole around the cable, moving the cable to get a good seal all around.

2. If the hole around the cable is excessively large, fill it with oakum and compress to make a tight seal.

3. Replace the original insulation.

FIGURE 11.21



Procedure 8

SEALING AROUND DUCTS PASSING INTO THE ATTIC/ROOF SPACE

TOOLS

- Caulking gun
- Knife
- Brush

MATERIALS

- Sealant: water based acrylic or silicone
- Duct tape
- MEK (methyl ethyl ketone) or mineral spirits
- Clean white rags
- Fast cure urethane foam

This Procedure outlines techniques for sealing around duct penetrations into the attic or roof space. The techniques are relevant for heating ducts (which in some houses run through the attic for a distance); for ducts associated with exhaust fans; and for ceiling exhaust fan receptacles.

Before beginning any sealing work, contractors should check to ensure that any ducts into the attic from exhaust fans are properly installed. Specifically these exhaust ducts should pass through the attic to the outside and should be insulated. If the ducts are vented into the attic or are uninsulated, these defects should be corrected before proceeding as outlined below.

PREPARATION:

1. Locate each duct that penetrates the ceiling, and inspect the installation.

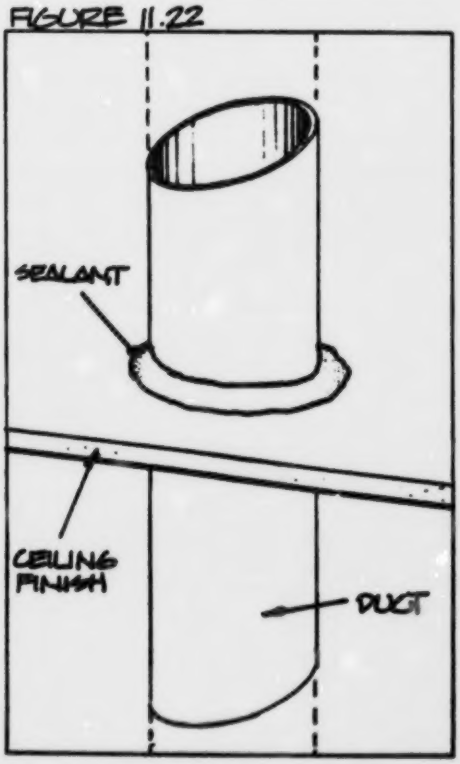
2. Remove ceiling insulation from around the duct, and use a brush to remove all loose material from the working area.

3. Use MEK and rags to clean the duct where it enters the attic/roof space. Similarly, clean the surrounding ceiling, vapour barrier, or top plate (as the case may be). Use mineral spirits instead of MEK on plastic or rubber surfaces and on electrical wiring (from the exhaust fan receptacle, for instance).

APPLICATION:

1. If the duct passes through the ceiling finish and if the gap around the duct is less than 6mm, apply a bead of water-based acrylic or silicone sealant to the gap, as shown in Figure 11.22. If the gap between the duct and the ceiling is greater than 6mm, it can be sealed either by applying a wide bead of fast-cure urethane foam or by using duct tape.

FIGURE 11.22

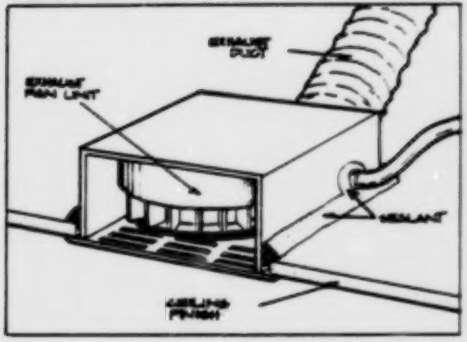


PROCEDURE 8 (continued)

SEALING AROUND DUCTS PASSING INTO THE ATTIC/ROOF SPACE

2. If, instead, the duct passes through the top plate of a partition wall, treat in the same way as a plumbing stack (Procedure 3 of this Worksheet). If oakum is used, it should not be compressed too tightly, since the thin walls of most ducts will buckle under pressure.

FIGURE 11.23

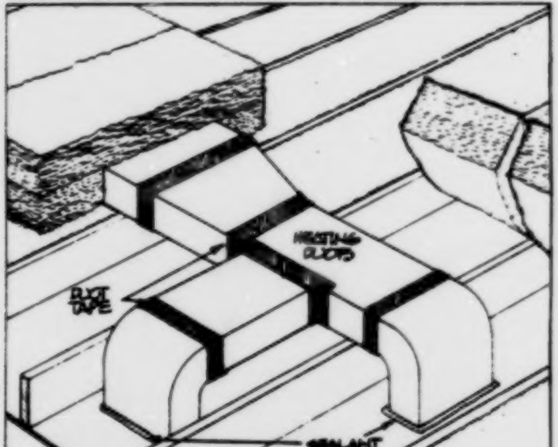


3. Steps 1 or 2, as appropriate, can be applied to the situation where an exhaust fan receptacle penetrates the ceiling, as shown in Figure 11.23. If the fan is fitted with a backdraft damper, it is worthwhile to check that it is operating properly (since an ineffective damper can allow unwanted air leakage).

4. In addition to steps 1 or 2, when dealing with a heating duct, all duct joints must be sealed (since leakage from such a duct is a source of heat loss). Wipe each joint with MEK, then apply duct tape as shown in Figure 11.24. A thorough seal is important.

5. Replace the original insulation. In the case of a heating duct, ensure that there is a good level of insulation surrounding the ducts, as shown in Figure 11.24.

FIGURE 11.24



Procedure 9

SEALING THE ATTIC HATCH

This Procedure outlines techniques for the sealing of an interior attic hatch.

TOOLS

- Screwdriver
- Knife
- Caulking gun
- Hammer
- Pry bar
- Saw
- Scissors
- Wire brush
- Plane

MATERIALS

- Sash locks
- Sealant: water-based acrylic or silicone
- Weatherstripping: closed cell self adhesive foam or plastic "V"
- Rigidboard or glass fibre batt insulation
- Screws
- Nails
- Adhesive
- MEK (methyl ethyl ketone)
- Sandpaper
- Plywood, as required

PREPARATION:

1. If application of exposed sealant around the attic hatch trim is unacceptable to the householder, remove the trim using a pry bar. If necessary, before removal use a knife to score the paint at the trim/ceiling joint, in order to prevent paint chipping and peeling.

2. Clean all surfaces to be sealed using a wire brush. Wipe with MEK.

3. Use a brush to clean the top of the framework that supports the hatch cover. If necessary, use sandpaper or a plane to provide an even surface. Wipe with MEK.

APPLICATION:

1. If the attic hatch trim has been removed, apply a uniform and continous bead of water-based acrylic or silicone sealant to the joint between the ceiling surface and the frame of the attic hatch, as shown in Figure 11.25. Re-install the trim using finishing nails.

2. Alternatively, if the trim has not been removed, seal the joints between the trim and the ceiling and between the trim and the attic hatch frame. In addition, seal the corner joints in the trim and in the attic hatch frame.

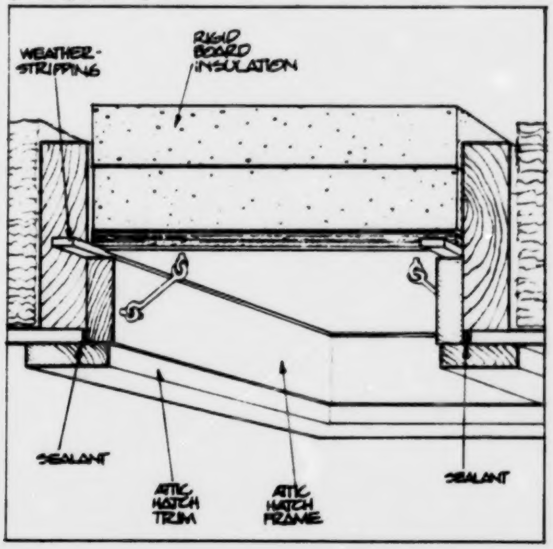
3. Apply a self adhesive closed cell foam weatherstripping material, or a plastic "V" weatherstrip, to the top surface of the framework which supports the hatch cover. Ensure that the corners of the weatherstripping fit tightly.

PROCEDURE 9 (continued)
SEALING THE ATTIC HATCH

4. Glue a piece of rigid insulation to the hatch cover. Be sure to use an adhesive compatible with the insulation material. Alternatively, construct a wood frame around the hatch cover and install a glassfibre insulation batt within the frame. Cover the frame and insulation with a plywood top.

5. Attach some sort of clamp or lock to the hatch cover and frame as shown in Figure 11.25. The device, when installed, should be able to pull the hatch tightly into the weatherstripping material, thereby providing a better seal.

FIGURE 11.25


WEATHER-
STRIPPING
RIGID
BOARD
INSULATION
SEALANT
ATTIC
HATCH
TRIM
ATTIC
HATCH
FRAME
SEALANT

Worksheet 2:

Procedures for inaccessible attics/roof spaces

INTRODUCTION

Many roof structures have no access into the roof cavity. Examples are cathedral or vaulted ceiling structures and some designs of flat roofs. Any sealing work on these structures must therefore be done from below. This has disadvantages in that it is not always possible to seal many of the air leakage openings without cutting through existing wall or ceiling surfaces. In low-cost sealing work, it is therefore not always possible to achieve a high level of airtightness at the ceiling.

In spite of this limitation, certain air leakage paths can be sealed without significant cost or disruption. Any air leakage gap that passes directly from a heated room to the roof space can generally be sealed from below. This category includes ceiling light fixtures and exposed chimneys (principally, chimneys from free-standing fireplaces and stoves). This Worksheet outlines the appropriate procedures:

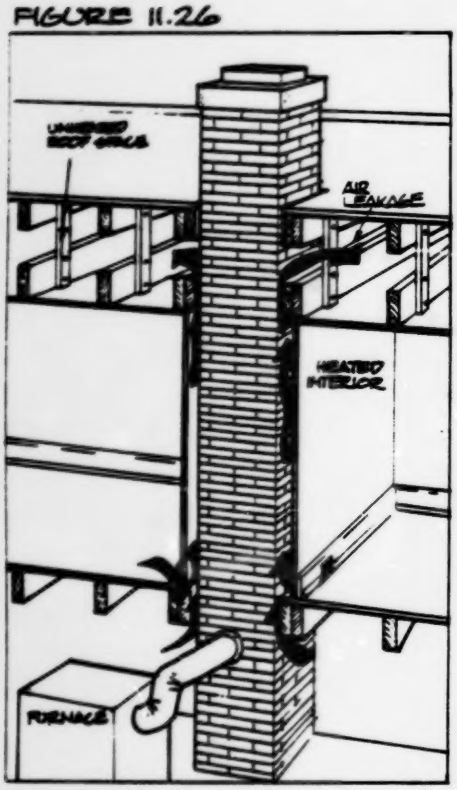
Procedure 1: Techniques for sealing a ceiling light fixture below an inaccessible roof space.

Procedure 2: Techniques for sealing an exposed masonry chimney below an inaccesible roof space.

Procedure 3: Techniques for sealing an exposed factory - built metal chimney below an inaccessible roof space.

In addition to lights and exposed chimneys, some houses may have other direct air leakage paths into an inaccessible roof space. For instance, contractors may find a leaky ceiling-mounted exhaust fan; these can sometimes be at least partly sealed with a bead of sealant. In other houses, the joint between the wall and the ceiling (specifically, the ceiling beneath the roof space) may not be sealed and taped. Though the resulting gap is normally concealed by a corner moulding, air leakage through the gap and into the attic is still likely. Such gaps should be sealed as described in Chapter 10.

FIGURE 11.26



Unfortunately, most air leakage paths into the roof space are much less direct. Most chimneys, for instance, are not exposed (except in the basement). Instead, they are concealed behind walls, in a configuration such as is shown in Figure 11.26. Any air leakage into the enclosure surrounding the chimney will usually escape readily into the roof space, since the enclosure is, in effect, a large air leakage channel running from the basement upwards.

Since the exit point into the attic is inaccessible, eliminating this leakage problem requires the sealing of those points where air enters the enclosure around the chminey. The most important of these entry points is in the basement, where the chimney passes through the basement ceiling. This Worksheet provides techniques for sealing at this point:

Procedure 4: Techniques for sealing an enclosed masonry chimney.

Procedure 5: Techniques for sealing an enclosed factory-built metal chimney.

The same general situation applies in the case of plumbing stacks. These generally run up from the basement inside a plumbing wall. The stack usually enters the wall through an oversized hole in the bottom plate. Sealing the gap between the stack and this bottom plate will reduce air leakage up the wall and into the roof space. This approach is less effective than the approach used in accessible attics (sealing at the top plate of the plumbing wall) but is the best option in the case of inaccessible attics.

INTRODUCTION (continued)

Sealing at the bottom plate can be achieved using the same oakum or polyethylene shroud techniques used at the top plate in the attic. Accordingly, no additional procedure is outlined here: the steps outlined in Worksheet 1 (Procedure 3) of this Chapter should be followed. In addition, any penetration from inside the house into the plumbing wall should be sealed if possible. For instance the drain pipe from a sink may pass through the plumbing wall and connect to the plumbing stack. Such points can normally be sealed simply by applying a bead of sealant. The choice of sealant will depend upon such factors as the location of the gap; the type of pipe and wall to which the sealant must adhere; and whether or not the pipe gets very hot. Chapter 7 should be referred to in sealant selection.

Sealing light fixtures, chimneys, plumbing stacks, and perhaps one or two other leakage paths is valuable - but it does not provide a complete seal of an inaccessible roof space. In particular, leakage via partition walls into the attic is likely to remain a problem. For a discussion of the sealing of indirect leakage paths, refer to Chapter 10, Worksheet 2.

Procedure 1

SEALING A CEILING LIGHT FIXTURE BELOW AN INACCESSIBLE ROOF SPACE

TOOLS

- Caulking gun
- Screwdriver

MATERIALS

- Sealant: oil or resin based caulk, coloured to match ceiling
- Clean white rags
- Mineral spirits

This Procedure outlines techniques for sealing lighting fixtures on the ceiling of inaccessible roof spaces. As with any electrical work, appropriate safety precautions should be taken.

Most ceiling light fixtures have some sort of plate - called a ceiling canopy - installed flush to the ceiling. The plate conceals the electrical receptacle above the light fixture. Air leakage occurs between the canopy and the ceiling, and through any holes in the canopy (notably holes for electrical cables).

If the appearance of the light is important, sealing probably should be conducted behind the canopy. Otherwise, it can be conducted around the edge of the canopy. In either case, a non-adhesive sealant should be used, since it is important that the plate be removeable (to allow for electrical repairs).

PREPARATION:

1. Remove the decorative shade or bowl (if any) from the light fixture. This allows easy access to the working area. Inspect to determine if sealing is required and, if so, determine where it is required.

2. If sealing is to be conducted under the canopy, use a screwdriver to loosen the locking screw. Gently pry the canopy from the ceiling surface. Inspect the canopy and ceiling to determine if an adequate seal can be obtained. If so, clean both surfaces with mineral spirits.

3. If, instead, the sealing is to be conducted around the edge of the canopy, simply use mineral spirits to clean the ceiling and canopy surface where sealant is to be applied.

PROCEDURE 1 (continued)

SEALING A CEILING LIGHT FIXTURE BELOW AN INACCESSIBLE ROOF SPACE

APPLICATION:

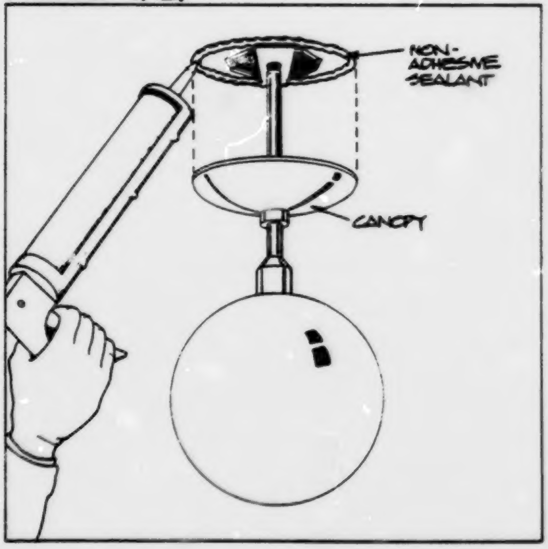
1. If the canopy has not been removed, simply apply a small bead of sealant around its edge. Finger tool if necessary.

2. If the canopy has been removed, apply a uniform and continous bead of sealant on the ceiling surface, following the outline of the canopy (see Figure 11.27). Re-install the canopy. The bead should have been applied so that the edge of the canopy contacts the sealant with a tiny amount of the sealant squeezed to the outside all around. Finger tool this exposed material and remove any excess.

3. If appropriate, work sealant into the gap around the electrical cables and into other holes that pass through the canopy.

4. Re-install shades or bowls on the fixture.

FIGURE 11.27



Procedure 2

SEALING AN EXPOSED MASONRY CHIMNEY BELOW AN INACCESSIBLE ROOF SPACE

FIGURE 11.28

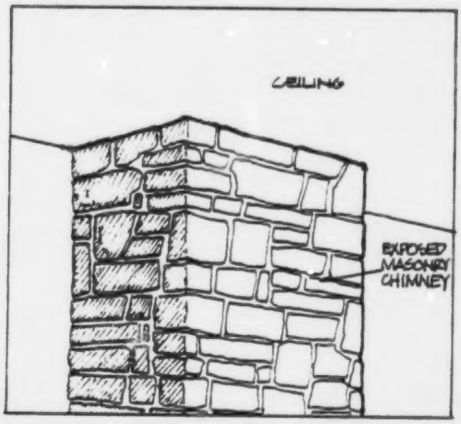


Figure 11.28 illustrates an exposed masonry chimney. Typically, the gap between the ceiling and the chimney will be small, and typically the ceiling will be made of material considered combustible in applications around chimneys (i.e. drywall or plaster on a wood lath). It is therefore not recommended to seal around such chimneys, since the National Building Code sets as a guideline a minimum 50mm space between the outside surface of any chimney and the nearest combustible surface.

Procedure 3

SEALING AN EXPOSED FACTORY-BUILT METAL CHIMNEY BELOW AN INACCESSIBLE ROOF SPACE

TOOLS

- Brush
- Caulking gun or putty knife
- Screwdriver
- Small pry bar

MATERIALS

- Muffler cement or other non-combustible sealant
- MEK (methyl ethyl ketone) or mineral spirits
- Clean white rags

This Procedure outlines a technique for sealing around an exposed factory-built metal chimney that passes through an inaccessible roof space. Note, however, that this Procedure may contravene the certification requirements and affect the safe performance of some chimneys. Therefore, before proceeding, always ensure that local codes, building material standards and the manufacturer's instructions permit the sealing procedures described here. Also ensure that the chimney is installed in such a fashion that a 50mm clearance from combustibles is maintained.

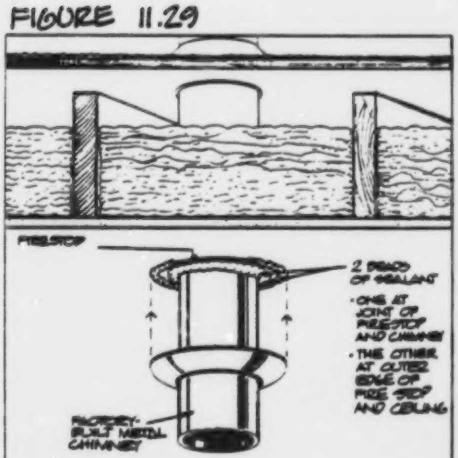
PREPARATION:

1. If possible, remove the chimney's flanged collar from the ceiling using a screwdriver or small pry bar as required. **Note that with some chimney types, the collar is an integral part of the chimney support system and cannot be removed.** In such cases, this technique cannot be used.

2. Inspect flanged collar and ceiling to ensure that the installation is suitable for the effective application of sealant.

3. If so, brush away loose material. Clean the surfaces to be sealed with MEK or mineral spirits.

FIGURE 11.29


FIRESTOP
2 BEADS OF SEALANT
• ONE AT JOINT OF FIRESTOP AND CHIMNEY
• THE OTHER AT OUTER EDGE OF FIRE STOP AND CEILING
FACTORY-BUILT METAL CHIMNEY

APPLICATION:

1. Apply muffler cement or other non-combustible sealant to the joint between the metal chimney and the metal firestop. Similarly, seal the joints between the metal firestop and the ceiling surface. See Figure 11.29.

2. Replace the flanged collar and fix it in place. Remove any protruding, excess sealant.

Procedure 4

SEALING AN ENCLOSED MASONRY CHIMNEY

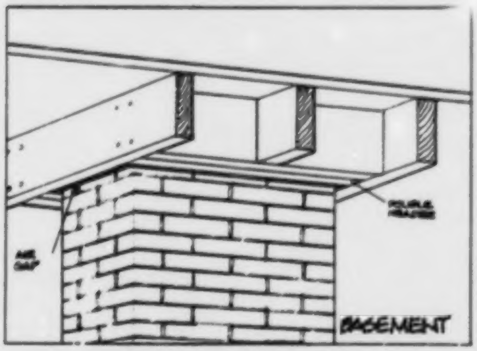
TOOLS

- Brush
- Hammer
- Caulking gun
- Metal cutters
- Putty knife

MATERIALS

- Sealant: silicone and acoustical
- Muffler cement or other non-combustible sealant
- MEK (methyl ethyl ketone)
- Clean white rags
- Thin galvanized metal sheet
- Nails

FIGURE 11.30



Note: while working in the basement, it may be convenient to carry out the plumbing stack work described in the introduction to this Worksheet.

This Procedure outlines a technique for sealing an enclosed masonry chimney at the point where it passes through the basement ceiling. (Figure 11.30 illustrates a typical situation). **Note that this technique should only be used on chimneys that conform to good building practice**: refer to Preparation step 1 below.

PREPARATION:

1. Inspect the gap between the chimney and the framing. In some cases the gap may be filled with combustible material or may be less than 50mm; in such cases, do not proceed with any sealing around the chimney (until the problem has been corrected), since this might increase the fire danger. In other cases, the gap may be adequately sealed with non-combustible material. If so, Application step 4 below should still be followed, but steps 1-3 are unnecessary. Note that insulation in the gap cannot be considered to provide an adequate seal.

2. Where the gap around the chimney is 50mm or more and requires sealing, use a brush to remove dust and debris from the working area. Clean all surfaces to which sealant will be applied, using MEK.

APPLICATION:

1. Apply a bead of acoustical sealant along the bottom face of the wood frame around the chimney.

2. Cut strips of metal sheet to fit around the chimney. Nail (or screw) these in place pressed into the sealant bead, so that they butt tightly to each other and against the chimney.

3. Apply muffler cement or another non-combustible sealant to the metal sheet joints and to the joints between the metal and the chimney. Make sure that a good seal is achieved.

4. Apply silicone sealant to the joints in the wood frame around the chimney.

Procedure 5

SEALING AN ENCLOSED FACTORY-BUILT METAL CHIMNEY

TOOLS

- Claw hammer
- Tin snips
- Caulking gun
- Brush
- Putty knife

MATERIALS

- Galvanized metal, if required for new firestop
- Sealant: silicone or water based acrylic
- Muffler cement or other non-combustible sealant
- MEK (methyl ethyl ketone) or mineral spirits
- Clean white rags
- Nails

This Procedure outlines the techniques for sealing enclosed factory-built metal chimneys at the point where they pass through the basement ceiling. Before sealing such chimneys, contractors should be aware of two limitations:

- First, the technique described may contravene the certification requirements and affect the safe performance of some chimneys. Therefore, before proceeding, always ensure that local codes, building material standards, and the manufacturer's instructions permit the sealing procedure described here.

- Second, the National Building Code sets as a guideline a minimum 50mm space between the outside surface of any chimney and the nearest combustible surface. Contractors finding construction that does not meet these guidelines should not proceed with any sealing around the chimney, until the problem has been corrected.

Figure 11.31 illustrates a typical situation. Note that the following work should be done only where similar sealing work cannot be done in the attic.

PREPARATION:

1. Inspect the chimney installation. Note that **with some chimney types, the firestop is an integral part of the chimney support system.** In such cases, the following steps should not be followed, since removal of the firestop could cause the chimney to fall, resulting in damage or personal injury.

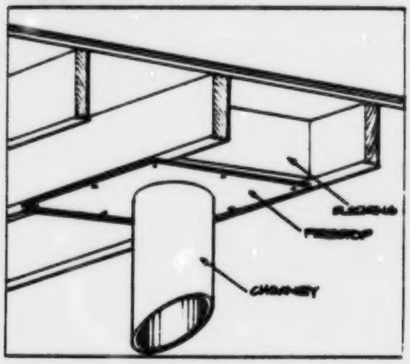
2. If the firestop is not part of the chimney support structure, inspect the firestop installation to determine if it fits well to the joists and blocking.

3. If it is a good fit, carefully remove the nails holding it in place and slide the loose firestop down the chimney so that it is out of the way.

PROCEDURE 5 (continued)

SEALING AN ENCLOSED FACTORY-BUILT METAL CHIMNEY

FIGURE 11.31


BLOCKING
FIRESTOP
CHIMNEY

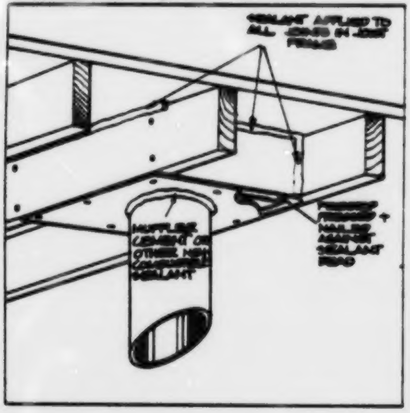
4. If the firestop fits poorly, use a hammer and tin snips to remove it completely. Prepare a new firestop out of galvanized steel, making it large enough to overlap the joist frame on all sides. The new firestop should be split in two halves to allow installation around the chimney.

5. Use a brush, MEK, and rags to clean all surfaces to be sealed.

APPLICATION: (See Figure 11.32)

1. Apply bead of water based acrylic sealant around the bottom face of the joist and blocking. Press the firestop (original or new, as the case may be) against the sealant, so that it makes a good fit around the chimney. Nail firmly in place.

FIGURE 11.32

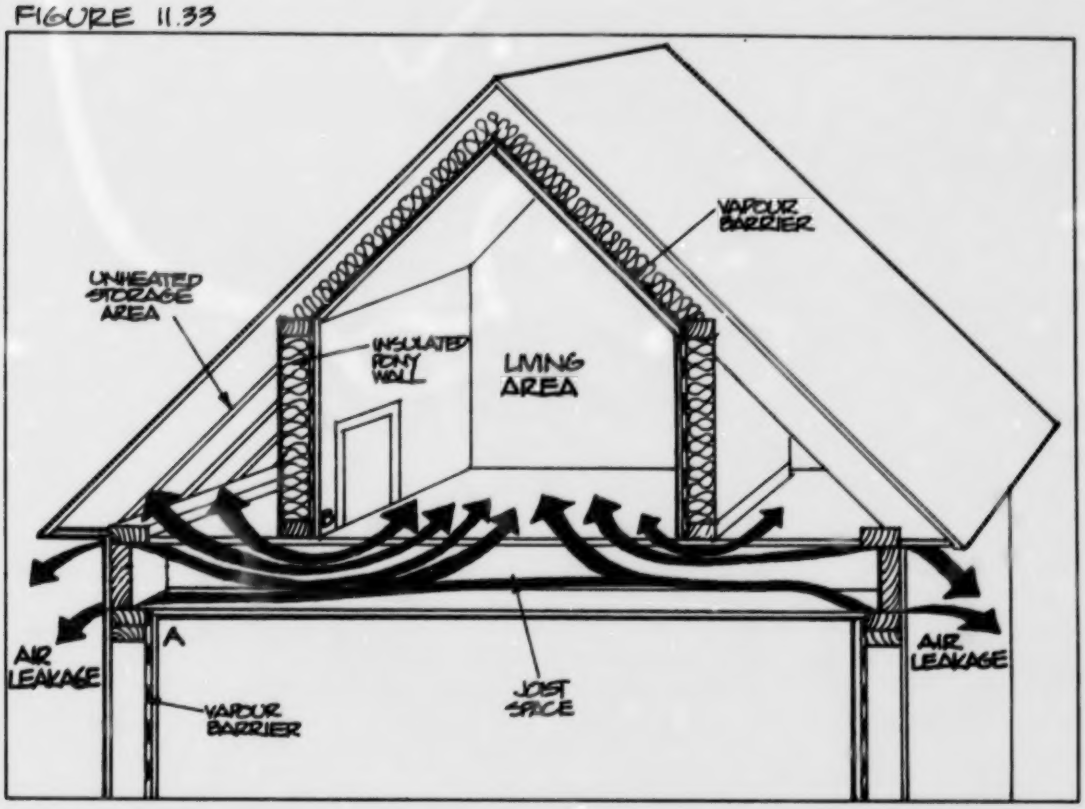

SEALANT APPLIED TO ALL JOINTS IN JOIST FRAME
MUFFLER CEMENT OR OTHER NON COMBUSTIBLE SEALANT
FIRESTOP PRESSED + NAILED AGAINST SEALANT BEAD

2. Apply water based acrylic or silicone sealant to the accessible joints in the joist frame around the chimney, to make a sealed enclosure. Specifically, the points to seal are the joist/subfloor, blocking/subfloor, and blocking/joist junctions.

3. Apply muffler cement or other non-combustible sealant around the joint between the firestop and the chimney. In the case of a new firestop, also apply non-combustible sealant along the joint between the two halves of the firestop.

(While working in the basement to seal the chimney, it may be convenient to carry out the plumbing stack work described in the introduction to this Worksheet.)

FIGURE 11.33


UNHEATED STORAGE AREA
INSULATED PONY WALL
LIVING AREA
VAPOUR BARRIER
B
AIR LEAKAGE
A
AIR LEAKAGE
JOIST SPACE
VAPOUR BARRIER

Worksheet 3:

Procedures for half-storey developments

INTRODUCTION AND PROCEDURES

A large number of houses have half-storey developments in the attic. These usually consist of one or two rooms, with triangular storage spaces on either side. There are many variations in design; Figure 11.33 illustrates a typical, 1940's style, with the storage area unheated.

This type of construction can have considerable air leakage. Part of the problem is air movement through the pony walls and through the ceiling above the half-storey living space. However, there is a larger problem.

The entire structure from the exterior walls (point A in Figure 11.33) to the pony walls (point B) is an area of air movement between the joist space and the unheated exterior. Furthermore, the floor under the half-storey living area is usually made of boards with a large number of cracks and gaps, which allow easy air movement between the heated rooms and the joist space. The resulting air leakage paths are illustrated in Figure 11.33. These paths can account for major heat loss.

Currently, there are no fully satisfactory and thoroughly evaluated techniques for sealing air flow through the joist space. However, there are a number of approaches that can cut the overall leakage somewhat. Because of the number of design variations encountered in half-storey construction, this Worksheet (unlike most of the others in this Manual) does not present these approaches in the form of specific procedures. Instead, an overview of two example approaches is provided below; contractors will need to carefully adapt these and other sealing techniques to the specific circumstances they encounter.

Option 1: General approach

(See Figure 11.34)

The unheated storage areas can be made of part of the heated envelope of the house:

1. Install (or upgrade) insulation between the roof rafters in each of the storage areas.

2. Install a continuous, sealed 0.150mm polyethylene air-vapour barrier as shown in Figure 11.34. Use acoustical sealant and staples to seal the barrier to the wood frame at the top and bottom. Cover with drywall or panelling.

3. Remove any original vapour barriers or insulation from the pony walls, or provide openings for good air circulation between the original heated rooms and the storage areas.

4. Seal any major air leakage gaps leading into the joist space from the upper rooms (adapting techniques presented elsewhere in this Manual, as required).

5. Seal the ceiling above the original living area using the techniques presented elsewhere in this manual.

Option 2: General approach

(See Figure 11.35)

The unheated storage areas can be retained as unheated space, with reduced air leakage. This technique should not be used if the floor below the storage area is filled with insulation.

FIGURE 11.34

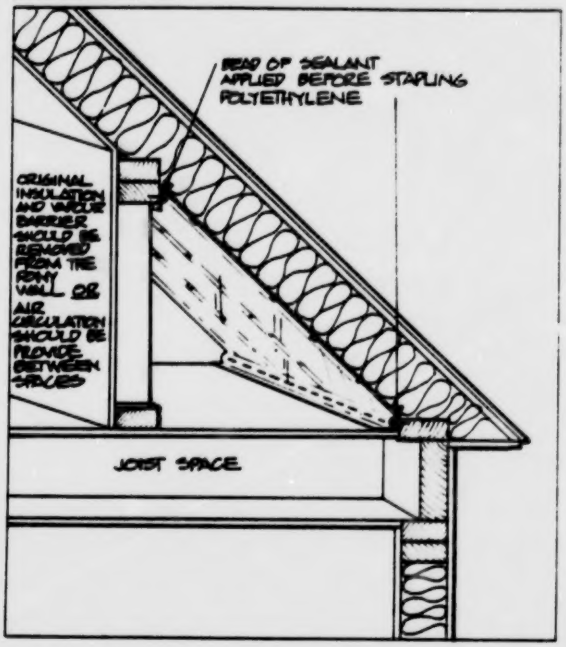
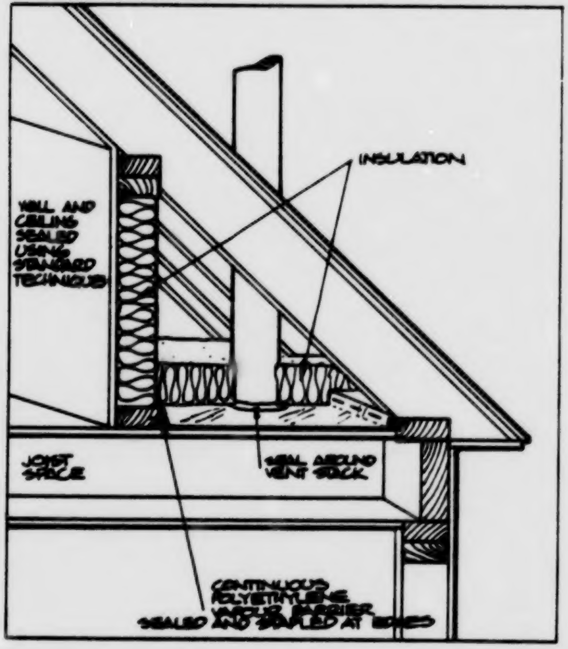

BEAD OF SEALANT APPLIED BEFORE STAPLING POLYETHYLENE
ORIGINAL INSULATION AND VAPOUR BARRIER SHOULD BE REMOVED FROM THE PONY WALL OR AIR CIRCULATION SHOULD BE PROVIDE BETWEEN SPACES
JOIST SPACE

FIGURE 11.35


INSULATION
WALL AND CEILING SEALED USING STANDARD TECHNIQUES
JOIST SPACE
SEAL AROUND VENT STACK
CONTINUOUS POLYETHYLENE VAPOUR BARRIER SEALED AND STAPLED AT EDGES

INTRODUCTION AND PROCEDURES (continued)

1. Install a continous, sealed 0.150mm polyethylene vapour barrier across the floor of the storage spaces. Seal and staple the barrier to the pony wall bottom plates and the bottom plates at the base of the rafters.

2. Where chimneys or vents pass through the storage space, seal all gaps around these where they pass through the new vapour barrier, using adaptations of the techniques presented in Worksheet 1 of this chapter.

3. Install insulation across the storage space floor. If the pony walls are poorly insulated, install insulation between the studs.

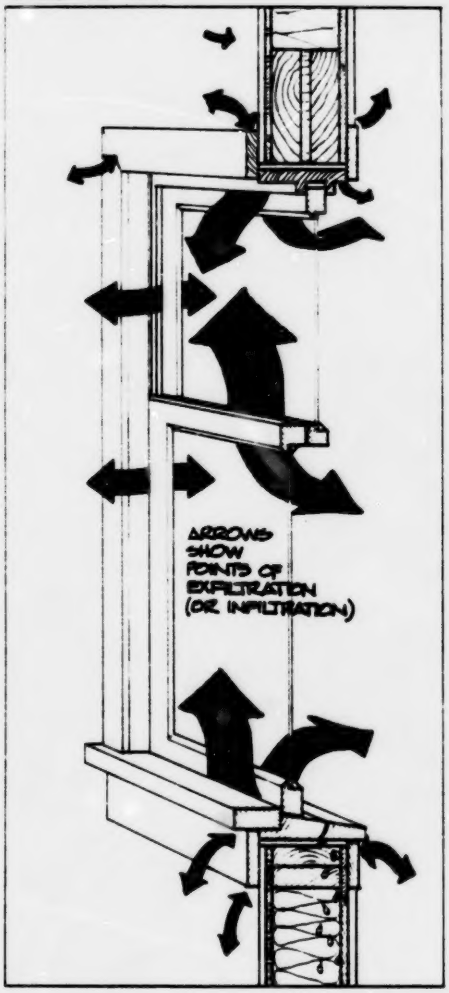
4. Convert all doors and hatches into the storage spaces into fixed and sealed units, or weatherstrip and clamp them using the techniques given for attic hatches in Worksheet 1 of this chapter.

5. Using techniques presented elsewhere in this Manual, seal cracks, gaps, electrical outlets, service penetrations, etc. in the walls and ceiling of the attic living space.

6. Seal any major air leakage gaps leading into the joist space from the heated rooms (adapting techniques presented elsewhere in this Manual, as required).

Chapter 12: Windows

FIGURE 12.1



Windows account for about 12% of the total heat losses from a "typical" house; in some houses the percentage is even higher. A significant portion of this loss can be caused by air leakage, as illustrated in Figure 12.1.

This Chapter describes the recommended sealing and weatherstripping techniques for the most common window types. Of the various measures that can be taken to cut window heat loss, the air sealing measures presented here are generally the most cost effective.

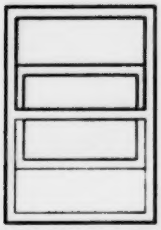
Note: Older windows may display a significant level of deterioration. In some cases the frame or sashes may have deteriorated to the point where sealing work would not be effective. In such cases, rehabilitation of the window is probably a prerequisite to the effective, durable sealing work described in this Chapter.

For definitions of specialized window terminology, refer to the glossary at the end of this Manual.

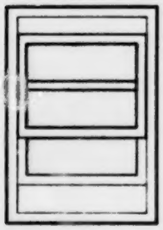
GUIDE TO THE WORKSHEETS

The following pages contain 6 Worksheets, each concerned with a different aspect of window sealing/weatherstripping. The Worksheets provide step-by-step guidance on the following topics:

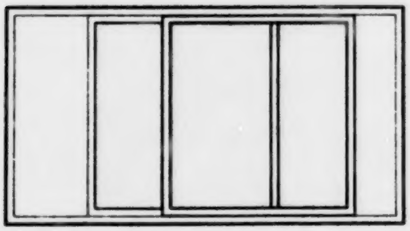
Procedures applicable to most **WINDOWS** . . . . . . Worksheet 1



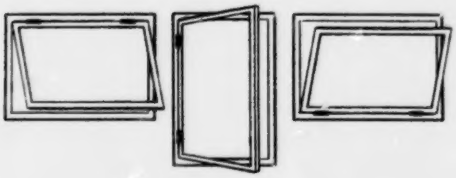
Additional procedures for **SINGLE HUNG WINDOWS** . . . . . . Worksheet 2



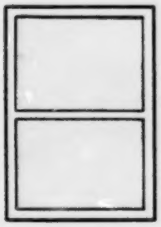
Additional procedures for **DOUBLE HUNG WINDOWS** . . . . . . Worksheet 3



Additional procedures for **SLIDING WINDOWS** . . . . . . Worksheet 4



Additional procedures
for **HINGED WINDOWS** . . . . . . Worksheet 5



Additional procedures
for **STORM WINDOWS** . . . . . . Worksheet 6

For each specific procedure described in each Worksheet, preparation and application requirements are described, step by step. In addition, the necessary tools and materials are identified in each case.

For most window sealing jobs, it will be necessary to refer to at least two Worksheets: Worksheet 1 (for common procedures) plus one other (for additional procedures specific to the window type). If the window is fitted with a storm, Worksheet 6 should also be consulted.

Worksheet 1:
Procedures common to most windows

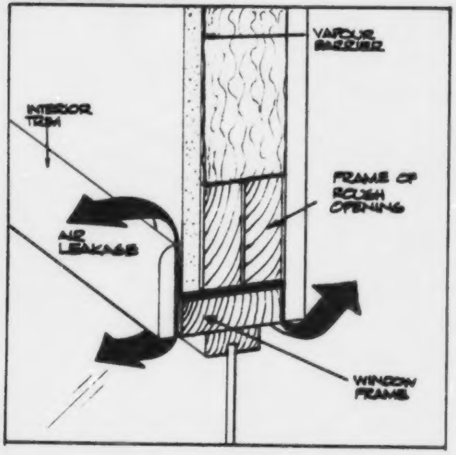
INTRODUCTION:

This Worksheet considers three points of air leakage that are common to a great many window installations, regardless of the type of window:

Air leakage around interior trim

In older houses there is often a considerable gap between the window frame and the rough opening in the wall. Some attempt may have been made to fill the space with loose pieces of insulation, but often the gap is empty. Either way, it usually provides an easy channel for air leakage.

FIGURE 12.2



Ideally, this channel should be blocked on the inside by the wall vapour barrier - but, in fact, this is rarely the case. Therefore, the only potentially important barrier to leakage through the gap is the interior trim. Unfortunately, this trim usually provides a very poor seal, allowing considerable leakage around its edges (as shown in Figure 12.2).

This Worksheet outlines two alternative Procedures designed to deal with this leakage:

Procedure 1: Techniques to seal around the interior trim without removal.

Procedure 2: Techniques to seal behind the interior trim.

Air leakage through the window frame and sash

Wood frame windows are made up of several components that are nailed, screwed, or glued together. Over a period of years, the various joints may open up and allow air leakage. This

INTRODUCTION (continued)

Worksheet describes the recommended approach to the problem:

> **Procedure 3:** Techniques to seal joints in the window frame and sash.

Air Leakage through deteriorated glass-to-wood joints and through broken or cracked glass

Glass is normally held in pace by putty or butyl rubber glazing compounds. These tend to dry out over a period of years, and may crack or fall out. When this happens, the panes may rattle, water damage may occur, and air may leak around the glass. Similar problems arise from broken or cracked glass.

The proper techniques for installing new glass and sealing around existing glass are re-affirmed in this Worksheet:

> **Procedure 4:** Techniques for glass-to-sash sealing.

In addition to the common techniques outlined in this Worksheet, the proper sealing of any window requires the use of additional techniques, as outlined for each of the various window types in Windows: Worksheets 2-6.

Procedure 1

SEALING INTERIOR TRIM WITHOUT REMOVAL

TOOLS

. Caulking gun

MATERIALS

. Sealant:
water-based
acrylic
(coloured to match) or
paintable silicon

. MEK (methyl ethyl
ketone)

. Soap, water, and clean
white rags.

(Additional tools and materials may be required if minor window repairs are necessary)

This Procedure covers the sealing of air leakage points around interior window trim, without removing the trim. The technique leaves exposed sealant and, consequently, may sometimes be rejected on aesthetic grounds.

PREPARATION

1. Inspect the trim. If the gap between the trim and the wall exceeds 3mm, use nails to attach the trim more closely to the wall.

2. Clean the outside edge of the trim and surrounding wall surface with soap and water to remove dirt and grease. Wipe with MEK.

APPLICATION

(See Figure 12.3)

1. Run a continuous bead of sealant around the gap between the window trim and the wall. Adjust the width of the bead according to the size of the gap. Good caulking technique is required to maintain a tidy bead.

2. Run a needle bead into the trim mitre joints, where required. Similarly, run a needle bead into any gap between the trim and the window frame. Remove excess sealant and wipe clean.

Procedure 2

SEALING BEHIND INTERIOR TRIM

TOOLS

- Knife
- Pry bar
- Nail punch
- Caulking gun
- Staple gun
- Utility Knife
- Scissors
- Scraper
- Hammer

MATERIALS

- Sealant for use with polythylene: high solids butyl rubber or acoustical sealant
- Sealant for other applications: water-based acrylic or silicone
- MEK (methyl ethyl ketone)
- Primer, if required
- Backer rods
- Clean white rags
- Glass fibre or mineral fibre insulation
- 0.150 mm polyethylene
- Nails

(Additional tools and materials may be required if minor window repairs are necessary)

This Procedure covers the sealing of the gap between the window frame and the surrounding wall, behind the interior trim. Though more difficult than the approach outlined in Procedure 1, this technique can be of value where the finished appearance of the window is important.

PREPARATION

1. Where necessary, score the trim paint with the knife, in order to prevent paint chipping and peeling when the trim is removed.

2. Remove the trim using the pry bar. A piece of plywood should be used as a leverage surface for the bar, so as to eliminate damage to the surrounding wall. Nails that resist removal can be punched through. After trim removal, any residual nails should be removed.

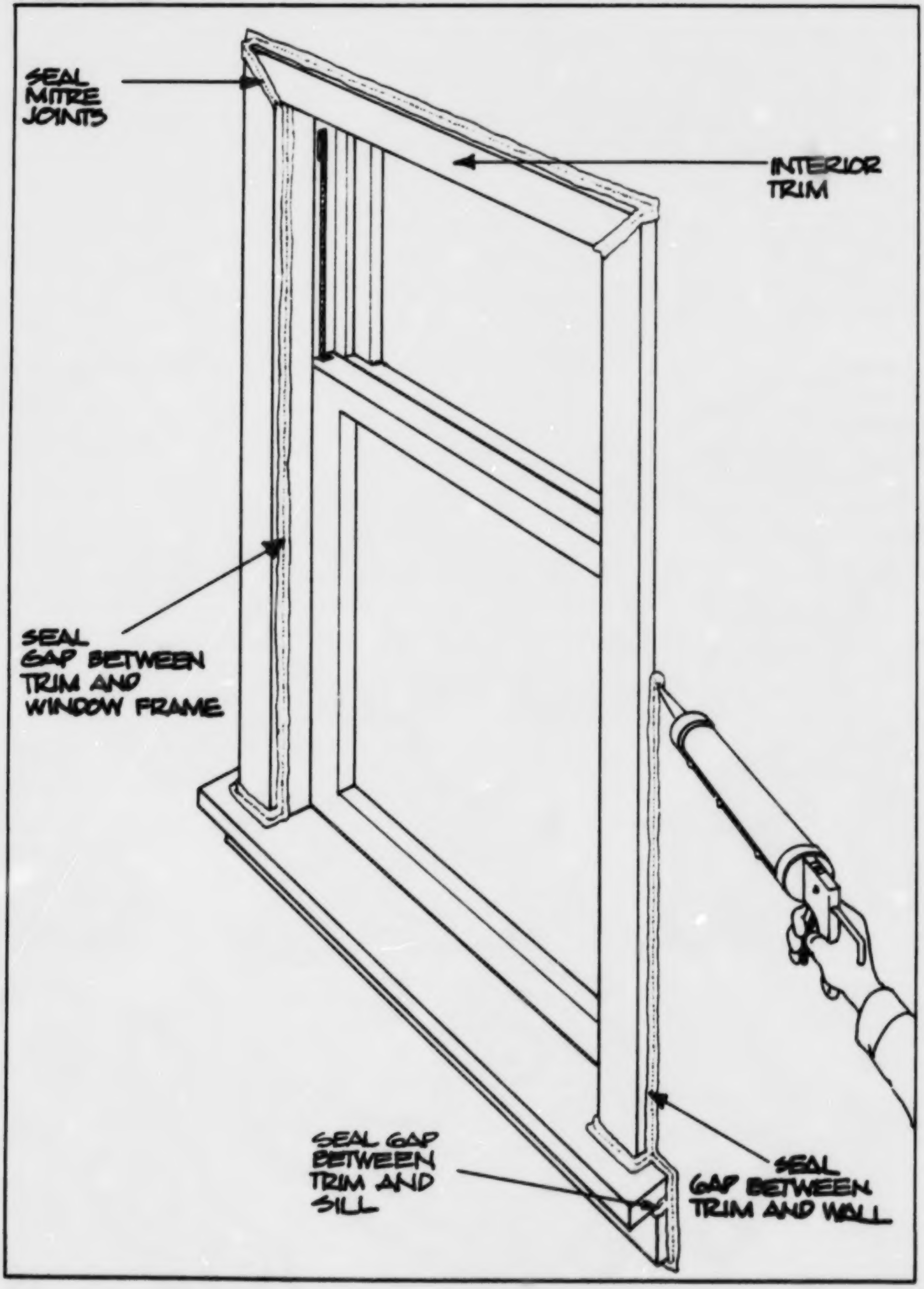
3. Inspect the gaps around the window frame. Where there are large, uninsulated gaps, work insulation into the gaps but do not compress. If the gap is greater than 25mm, foam insulation may be used (if care is taken to allow for expansion of the foam).

4. Clean the frame and surrounding wall with MEK, to remove dirt and grease. Remove any excess paint with the scraper. Prime if required, following the sealant manufacturer's instructions.

APPLICATION

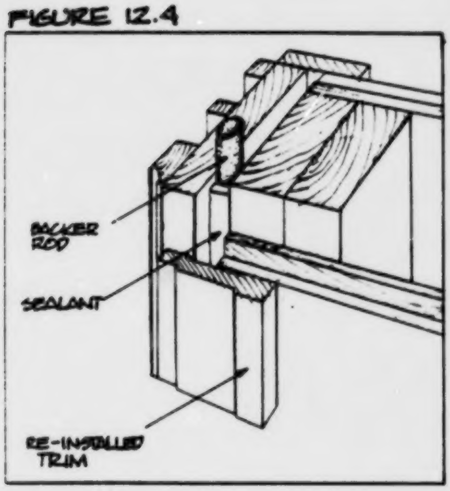
1. Where the gap between the frame and wall is less than 3mm, simply apply a bead of sealant (water-based acrylic or silicone) to fill the gap.

FIGURE 12.3


SEAL MITRE JOINTS
INTERIOR TRIM
SEAL GAP BETWEEN TRIM AND WINDOW FRAME
SEAL GAP BETWEEN TRIM AND SILL
SEAL GAP BETWEEN TRIM AND WALL

PROCEDURE 2 (continued)
SEALING BEHIND INTERIOR TRIM

FIGURE 12.4



2. Where the gap is 3mm to 6mm wide, insert a backer rod into the gap, to a depth not greater than 6mm. Apply the water-based acrylic or silicone sealant against the backing rod, so as to make a good seal between the wall and the window frame. See Figure 12.4.

3. Where the gap is wider than 6mm it should be sealed using strips of 0.150mm polyethylene. The strips should be attached by running a bead of the acoustical or high solids butyl rubber sealants along both the window frame and the wall. Press the polyethylene strips into the sealant and staple every 150mm. Hammer the staples flush.

4. Inspect the seals. If the window has been sealed using more than one of the above options, make sure that the seal is continuous where the techniques change.

5. Re-install the trim. Remove any protruding polyethylene or sealant.

Procedure 3

SEALING STRUCTURAL JOINTS

TOOLS

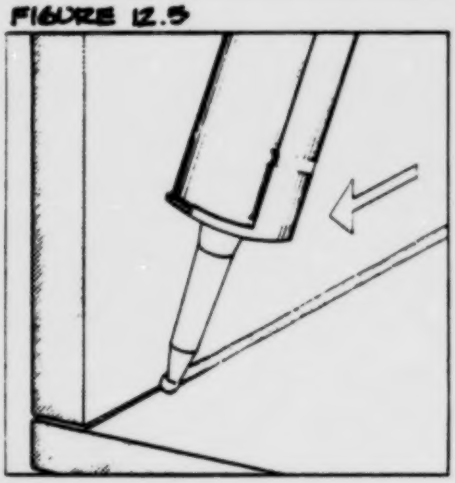
- Caulking gun

MATERIALS

- Sealant: water-based acrylic (coloured to match) or paintable silicone.
- MEK (methyl ethyl ketone)
- Clean white rags

(Additional tools and materials may be required if minor window repairs are necessary)

FIGURE 12.5



This Procedure covers the sealing of structural joints in the frame and sash of wood-frame windows.

PREPARATION

1. Identify any structural joints that appear to have air leakage gaps.

2. Attempt to close the joint using screws or nails. If successful, the joint can be sealed by applying a new coat of paint.

3. If the procedure is not successful, clean the area around all gaps with MEK, using a clean white rag.

APPLICATION

(See Figure 12.5)

1. Apply a fine bead of sealant along each crack, and work the sealant into the cracks.

2. Wipe off any excess and allow the sealant to cure.

Procedure 4

GLASS TO SASH SEALING

TOOLS

- Putty knife
- Wire brush
- Caulking gun
- Hammer

MATERIALS

- Sealant: paintable silicone or water-based acrylic
- MEK (methyl ethyl ketone)
- Primer, if required
- Clean white rags
- Glazing points
- Wood stop and nails, (channel technique only)

Note: Putty and butyl rubber sealants have been widely used in the glazing of windows. However, they are not recommended as they tend to dry out and crack, becoming ineffective.

(Additional tools and materials may be required if minor window repairs are necessary)

This Procedure presents the proper techniques for installing new glass and sealing around existing glass (when the original seal has deteriorated). Three satisfactory application techniques are presented.

PREPARATION

1. Thoroughly brush clean the glass-sash joint, removing all loose paint, dirt, and old glazing material.

2. Remove glass (except in the case of the first application technique noted below, which does not require glass removal).

3. Wipe areas to be sealed with a white rag moistened with MEK. Wipe with a clean rag to remove residue. Prime if required, following the sealant manufacturer's instructions.

APPLICATION: Face and back sealing technique

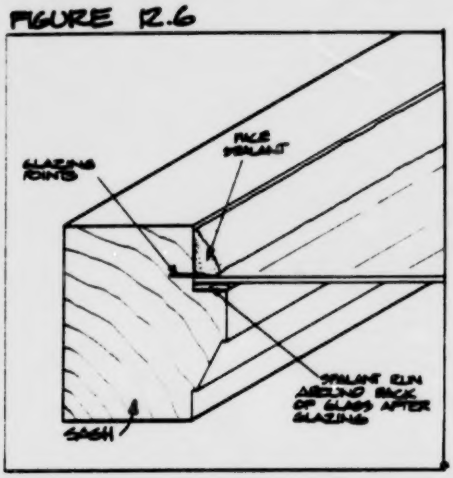
(See Figure 12.6)

1. Ensure that the glass is fully inserted in the proper position and is securely fixed with glazing points.

2. The recess in which the glass sits is known as a rabbet. To apply the "face seal", fill the rabbet with sealant and smooth the sealant surface against the sash with a putty knife.

3. After the sash has been face sealed, back sealing should be conducted. Run sealant around the edge of the glass on the reverse side. Work it into any gaps with a putty knife. Wipe away any excess.

FIGURE 12.6


GLAZING POINTS
FACE SEALANT
SEALANT RUN AROUND BACK OF GLASS AFTER GLAZING
SASH

APPLICATION: Bedding technique

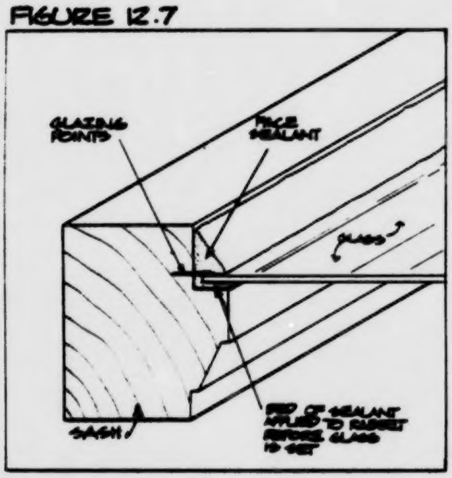
(See Figure 12.7)

1. Apply a thin layer of sealant in the rabbet (the recess in which the glass will sit) to form a bed for the glass. Press the glass into the bed and secure with glazing points.

2. Face-seal the glass as described above.

3. Trim off any excess sealant that has been squeezed out on the reverse side of the glass.

FIGURE 12.7


GLAZING POINTS
FACE SEALANT
GLASS
BED OF SEALANT APPLIED TO RABBET BEFORE GLASS IS SET
SASH

APPLICATION: Channel technique

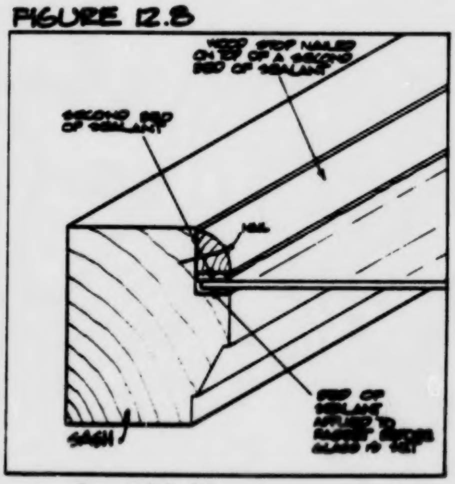
(See Figure 12.8)

1. Apply a thin layer of sealant in the rabbet to form a bed for the glass. Press the glass into position.

2. Apply a second bead of sealant along the corner between the glass and the sash.

3. Install wood stops and nail securely in place. Remove excess sealant.

FIGURE 12.8

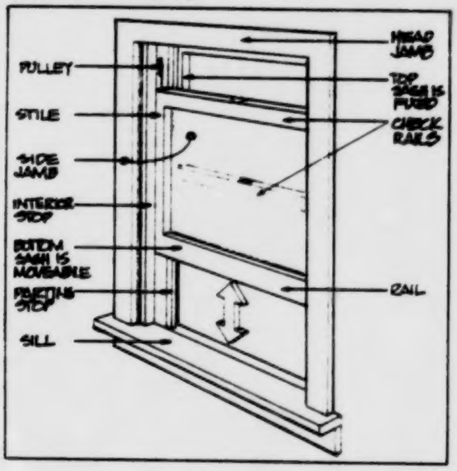

WOOD STOP NAILED ON TOP OF A SECOND BED OF SEALANT
SECOND BED OF SEALANT
NAIL
BED OF SEALANT APPLIED TO RABBET BEFORE GLASS IS SET
SASH

Worksheet 2:

Additional procedures for single-hung windows

INTRODUCTION:

FIGURE 12.9


HEAD JAMB
PULLEY
TOP SASH IS FIXED
STILE
CHECK RAILS
SIDE JAMB
INTERIOR STOP
BOTTOM SASH IS MOVEABLE
RAIL
PARTING STOP
SILL

Single-hung windows are very common in older houses. They have one fixed and one moveable sash, as illustrated in Figure 12.9. The moveable sash slides up and down in the frame, often with the aid of a pair of counterweights and pulleys.

In addition to the types of air leakage dealt with by Windows: Worksheet 1, in single hung windows the problem of air leakage around the moveable sash must be dealt with. Windows that do not need to open can be permanently sealed; others should be weatherstripped.

This Worksheet outlines the two relevant Procedures:

Procedure 1: Techniques to permanently seal the moveable sash.

Procedure 2: Techniques to weatherstrip the moveable sash.

Note that these procedures are concerned with single-hung **wood-frame** windows. Other types of single-hung windows (aluminum frame for instance) are not covered by this Worksheet. For some such windows the techniques for replacing pile weatherstripping (Windows: Worksheet 4) may be useful.

Procedure 1

PERMANENTLY SEALING THE MOVEABLE SASH

TOOLS

- Knife
- Pry bar
- Nail punch
- Caulking gun
- Scraper
- Electric drill
- Drill bits and countersinks
- Screwdriver
- Wire brush
- Putty knife

MATERIALS

- Sealant: water-based acrylic or silicone
- MEK (methyl ethyl ketone)
- Primer, if required
- Clean white rags
- Screws
- Latex wood filler

(Additional tools and materials may be required if minor window repairs are necessary)

This Procedure outlines the steps necessary to convert the moveable sash into a fixed and well-sealed unit. It should only be used where the window is not required for ventilation.

There are two ways of sealing around the sash. The first is to seal around the edges of the sash when it is closed. The second is to remove the sash and install sealant where it will be concealed when the sash is closed. The second technique is neater and is preferable. The following steps are based on this second technique.

PREPARATION

1. If necessary, use a knife to score the paint along the line where the interior stops meet the window frame. This will prevent paint chipping or peeling when the stop is removed.

2. Remove the interior stops using a putty knife or, if necessary, a pry bar. Punch nails through the stops if they resist removal. Remove the sash clamp.

3. Remove the lower sash. If the window is fitted with pulleys and counterweights, cut the cords and feed the ends through the pulley holes.

4. Brush all loose paint, dirt, sealants, etc. from the sash, from the exposed sill and jambs, and from the check rail of the upper sash.

5. If necessary, repair defective woodwork with latex wood filler. Sand uneven surfaces.

PROCEDURE 1 (continued)
PERMANENTLY SEALING THE MOVEABLE SASH

6. Clean surfaces to which sealant is to be applied using a clean white rag soaked in MEK. Apply primer if required, following the sealant manufacturer's instructions.

APPLICATION

1. Apply a bead of sealant to the two parting stops, the sill, and the check rail of the upper sash. The bead should be applied so as to provide a continuous seal when the lower sash is re-installed.

2. Re-insert the lower sash. Drill countersunk holes through the bottom rail into the sill, working from outside the house. Additional countersunk holes can also be drilled through the check rails, working from inside. Insert screws and fasten the window firmly in place.

3. Re-install the interior stops.

4. Seal the pulley holes where applicable. In some cases this may be achieved by removing the pulley and sealing the opening. In other cases, sealant may be applied to the air leakage gaps around the pulleys, without removal. In either case, if silicone sealant is used it should be paintable silicone. (Paintability is not critical in the hidden application identified in Step 1 above).

Procedure 2

WEATHERSTRIPPING THE MOVEABLE SASH

TOOLS

- Putty knife
- Nail punch
- Plane
- Scraper
- Hammer
- Small pry-bar
- Chisel
- Stapler
- Caulking gun
- Knife
- Sandpaper

MATERIALS

- Narrow "V" plastic weatherstrip
- Compression weatherstrip: closed cell sponge strip or hollow core tubular strip
- Sealant: silicone or water-based acrylic
- Latex wood filler
- Mineral spirits
- 10 mm staples
- Clean white rags
- Dry lubricant

(Additional tools and materials may be required if minor window repairs are necessary)

This Procedure describes how to weatherstrip the moveable sash of a single-hung wood-frame window. Weatherstripping will reduce leakage around poorly sealed sashes, when the homeowner wants to retain the window as an operable unit.

PREPARATION

1. Inspect the gap between the sash and the side jambs of the window, in order to determine the size of the space to be weatherstripped. Similarly, inspect the gap between the check rails of the two sashes, when the window is closed.

2. Score the paint along interior window stops where necessary, to avoid paint chipping or peeling when the stop is removed.

3. Remove interior stops with a putty knife or, if necessary, a pry bar. Punch nails through stops if these resist removal.

4. Remove the lower sash, taking care with sash cords, if present.

5. Clean all moving surfaces and visible cracks with rags and mineral spirits.

6. Use a plane and scraper to prepare smooth wood surfaces where the weatherstripping is to be applied.

7. Fill large indentations on sills, jambs, and rails, using latex wood filler. Sand smooth.

FIGURE 12.10

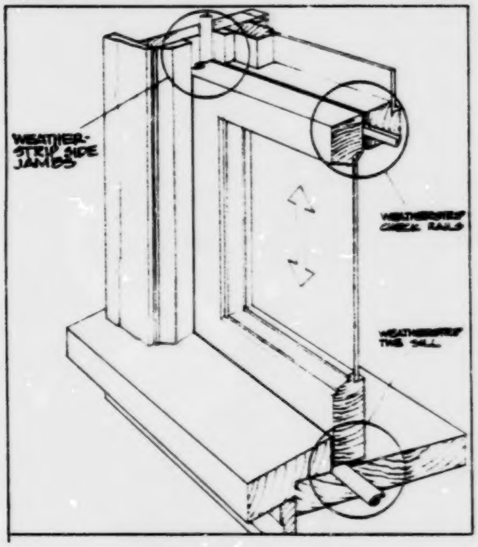
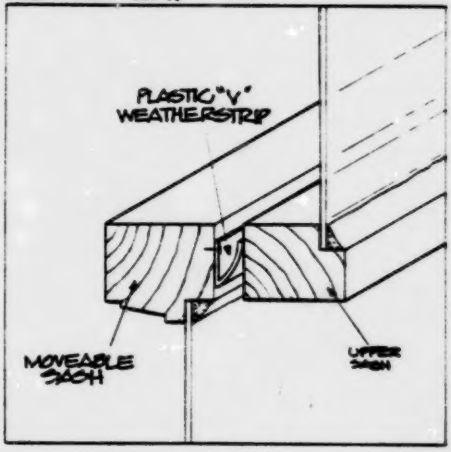

WEATHER-
STRIP SIDE
JAMBS
WEATHERSTRIP
CHECK RAILS
WEATHERSTRIP
THE SILL

FIGURE 12.11


PLASTIC "V"
WEATHERSTRIP
MOVEABLE
SASH
UPPER
SASH

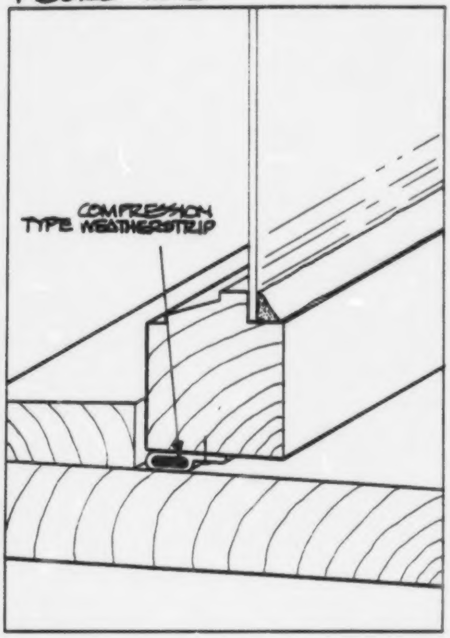
APPLICATION

1. Figure 12.10 illustrates the areas to be weatherstripped

2. To weatherstrip the check rails, apply plastic "V" weatherstrip to the back of the check rail on the lower sash, so that the strip is concealed when the sash is closed (see Figure 12.11). Staple through the weatherstrip every 150mm, and hammer the staples flush to ensure a firm mount.

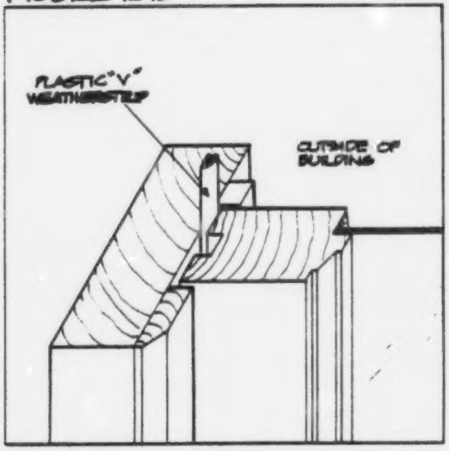
3. To weatherstrip at the sill, cut compression weatherstrip (closed cell sponge or hollow core tubular) to the exact width of the sash. Attach securely to the bottom rail of the sash, as shown in Figure 12.12.

FIGURE 12.12



4. To weatherstrip the sides of the sash, use self-adhesive plastic 'V' weatherstrip. Apply it to the side jambs, running up from the sill to the full height of the lower sash. The weatherstrip should be positioned as close to the outside of the house as possible, with the open end of the "V" facing to the outside (as shown in Figure 12.13). Staple through the weatherstrip every 150mm and hammer the staples flush.

FIGURE 12.13



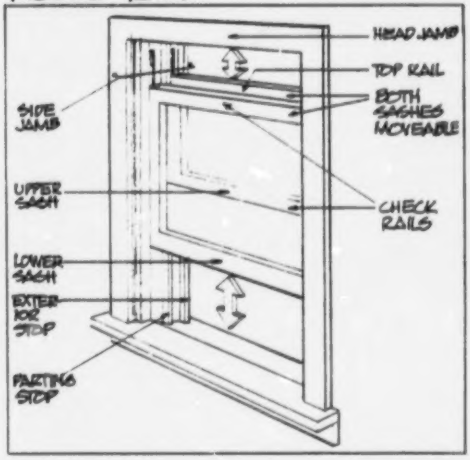
5. Re-install the sash. Replace the interior stops and install a new sash clamp if required.

6. Check to ensure that the window can still be opened easily. If not, apply a dry lubricant and adjust the stops as required.

Worksheet 3:
Additional procedures for double-hung windows

INTRODUCTION AND PROCEDURES

FIGURE 12.14



Double-hung windows are similar to the single-hung type (see Windows: Worksheet 2) but both sashes can be moved independently, as illustrated in Figure 12.14.

In addition to the types of air leakage dealt with by Windows: Worksheet 1, in double-hung windows the problem of air leakage around both moveable sashes must be dealt with. This Worksheet discusses techniques for the case of a double-hung **wood frame** window. Procedures for other types of double-hung window are not convered here. For some such windows, the techniques for replacing pile weatherstripping (Windows: Worksheet 4) may be useful.

In the case of a wood frame unit, there are two basic sealing options:

Permanent sealing

A moveable upper sash provides ventilation. However, ventilation may not be required at all, or the lower sash may provide all that is needed. In this case the upper sash can be converted to a fixed-sealed unit and the lower sash can be treated in the same way as the lower sash in a single-hung window (i.e. sealed or weatherstripped).

Sealing the upper sash should be handled in the same general way as the sealing of a lower sash. Accordingly, no separate procedure is identified in this Worksheet. The steps outlined in Windows: Worksheet 2, Procedure I should be followed, with the following modifications:

- Removal of the **upper** sash should be accomplished by removing the **exterior** stops

- After sash removal, sealant should be applied to the parting stops and the head jamb

- The sash should be re-installed and fixed in place using countersunk screws running diagonally through the top rail into the head jamb

- The pulley system for the upper sash (if any) can be left in place if it does not interfere with the effectiveness of the seal.

Weatherstripping

If the householder wishes to retain a fully openable unit, the upper sash should be weatherstripped rather than sealed. Once this work is completed, the lower sash should also be weatherstripped, following the procedures for a single hung window.

Weatherstripping the upper sash should be handled in the same general way as weatherstripping a lower sash (see Figure 12.15). Accordingly, no separate procedure is identified in this Worksheet. The steps outlined in Windows: Worksheet 2, Procedure 2 should be followed, with the following modifications:

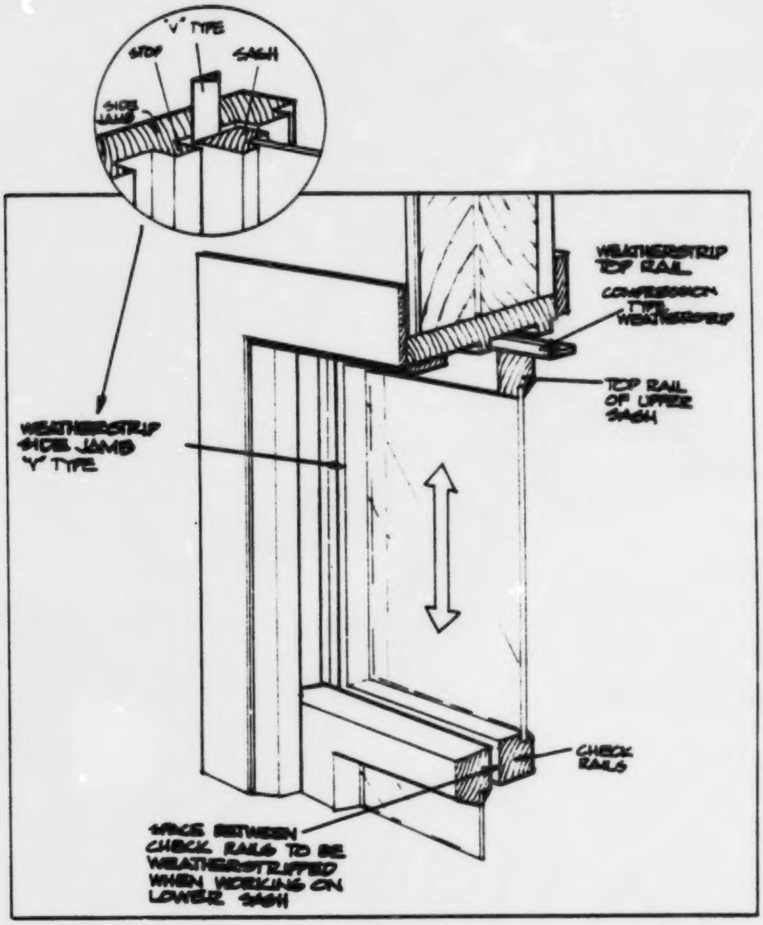
- Removal of the upper sash should be accomplished by removing the exterior stops

- Compression weatherstrip should be applied to the top rail of the sash

- No weatherstrip need be applied to the check rail, since the check rail of the lower sash will be treated

- Plastic weatherstrip should be applied to the side jambs, in the same fashion as in the case of a lower sash.

FIGURE 12.16


"V" TYPE
STOP
SASH
SIDE JAMB
WEATHERSTRIP TOP RAIL
COMPRESSION TYPE WEATHERSTRIP
TOP RAIL OF UPPER SASH
WEATHERSTRIP SIDE JAMB "V" TYPE
CHECK RAILS
SPACE BETWEEN CHECK RAILS TO BE WEATHERSTRIPPED WHEN WORKING ON LOWER SASH

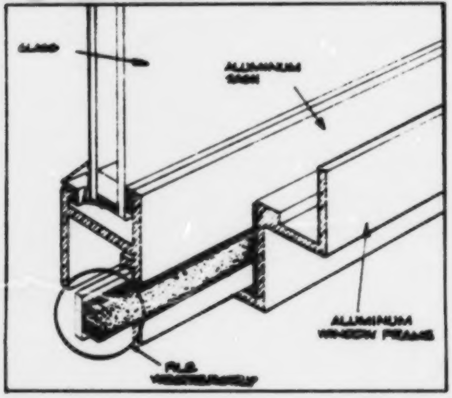
Worksheet 4:
Additional procedures for sliding windows

INTRODUCTION

Sliding windows consist of a frame with two or more glass units that slide horizontally in the frame. The glass units (or "sliders") may or may not have their own framework of wood, metal, or plastic. If present, such a framework is known as the sash; if absent, the window is referred to as sashless.

In addition to the types of air leakage dealt with Windows: Worksheet 1, in sliding windows the problem of air leakage around the moveable glass units must be dealt with. The techniques for sealing windows with sashes are different from the techniques for sashless sliders. Both are considered in this Worksheet:

FIGURE 12.16



Sliders with sash

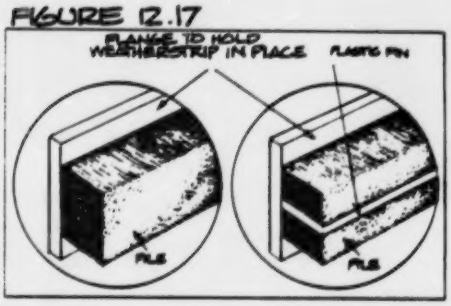
Sliders with sash come in a variety of forms, including:

- Aluminum sashes sliding in aluminum tracks
- Wood sashes in wood tracks
- Metal sashes in plastic tracks.

Most recently manufactured windows of these types were originally supplied with pile weatherstripping as a means of stopping air leakage. The pile may be attached to the sash, the track, or both. It is normally held in place by a flange that is inserted in a slot or groove in the sash or track. Figure 12.16 illustrates one typical configuration.

INTRODUCTION (continued)

FIGURE 12.17



The density and height of the pile varies according to the quality of the window. Denser piles have greater durability and give more effective seals. The weatherstrip may have a simple design or it may be fitted with a plastic fin that improves its effectiveness (Figure 12.17).

Pile weatherstripping becomes ineffective when it loses 2.0mm to 2.5mm in height - which it can as a result of normal wear and tear. Such worn weatherstripping should be replaced.

Best replacement results are obtained by matching the new weatherstrip to the original. This allows the new strip to fit easily into the existing grooves. To obtain matching materials, contact the window manufacturer, take a sample of the old pile to a weatherstripping supplier, or carefully measure pile dimensions and provide this to the supplier. In the last instance an extra 20% to 30% should be allowed on the pile height to account for wear.

The techniques for replacing pile seals are fairly standard in all the sliding window types in which they are installed. In this Worksheet, the procedure is presented using the example of an aluminum sash unit in an aluminum track, but the description has wider applicability:

> **Procedure 1:** Techniques to replace pile weatherstripping in a sliding window with sash.

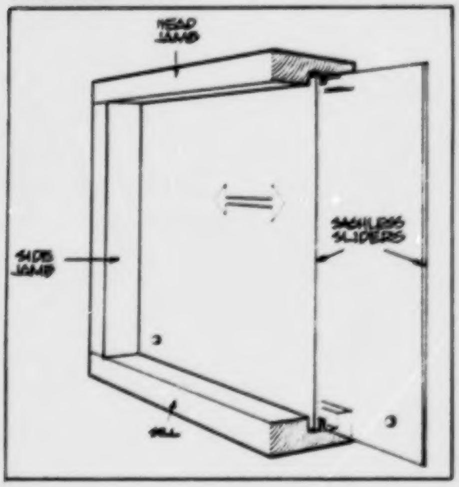
(Note that Procedure 1 can, with adaptation, be used for those single and double hung windows that use pile weatherstripping. Many aluminum frame double hung windows, for instance, fall into this category.)

Instead of pile, contractors may occasionally encounter an uncommon type of weatherstripping or seal on the sash or frame of a sliding window. In such cases, if replacement is required, it is necessary to devise special sealing techniques that fit the circumstances. Plastic "V" weatherstripping, for instance, can often be used. No procedures for such uncommon situations are included in this Worksheet.

Sashless Sliders

The most common sashless slider design utilizes a glass slider that moves in a plastic track set in a wood frame. Some designs are even simpler, with grooves in the wood frame serving as the tracks for the sliding glass. Figure 12.18 shows a typical configuration.

FIGURE 12.18



In older sashless units there may be no weatherstripping at all around the sliding sections. In newer units some weatherstripping may have been applied in an effort to reduce air leakage. The seals around the outside of the sliders may be either pile type or plastic "V" weatherstrip, attached to the sides of the track. Plastic "V" weatherstrip may also have been applied to the overlapping edges of the two sliding glass units.

Installation of new or replacement weatherstripping will cut air leakage in any existing window where no seals exist, or where the original weatherstripping has deteriorated. Deterioration includes damage to the original materials and routine wear. Pile weatherstripping, in particular, becomes ineffective when it loses 2.0mm to 2.5mm in height.

As an example of the general approach to the problem of sashless sliders, this Worksheet outlines measures for the specific case of a sashless slider in a wood track.

Procedure 2: Techniques to replace weatherstripping in a sashless sliding window.

Procedure 1

REPLACING PILE WEATHERSTRIPPING IN SLIDING WINDOW WITH SASH

TOOLS

- Knife
- Pliers
- Screwdriver

MATERIALS

- Pile weatherstripping to match original

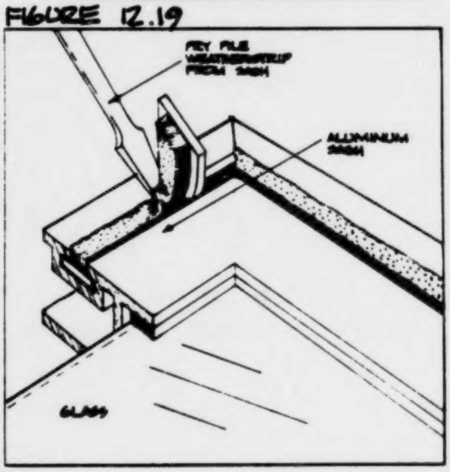
(Additional tools and materials may be required if minor window repairs are necessary)

This procedure is based on the example of an aluminum sliding window with weatherstripping attached to the sash, as illustrated previously in Figure 12.16. However, the procedure gives general guidance on how to replace pile weatherstripping in windows of various types.

PREPARATION

1. Remove the sliding unit from its track.
2. Working at a corner, push the blade of a screwdriver under the existing weatherstrip, forcing it out of the groove (see Figure 12.19). Beginning with this free edge, use pliers to pull out the full strip.
3. Repeat all around the aluminum sash.

FIGURE 12.19



APPLICATION

1. Cut a mitred end on the new pile as shown in Figure 12.20. Place one edge of the backing into the groove on the sash, with the mitred end aligned with the corner of the sash.
2. Beginning at the mitred corner, push down on the pile surface to snap it into place, as shown in Figure 12.21. Continue along the sash to the next corner
3. Cut the installed strip to the proper length, so that it gives a close fit into the corner. The cut should be mitred.
4. Use the same techniques along the other sides of the aluminum sash, making sure that good mitred joints are obtained at each corner.

PROCEDURE 1 (continued)
REPLACING PILE WEATHERSTRIPPING IN SLIDING WINDOW WITH SASH

FIGURE 12.20

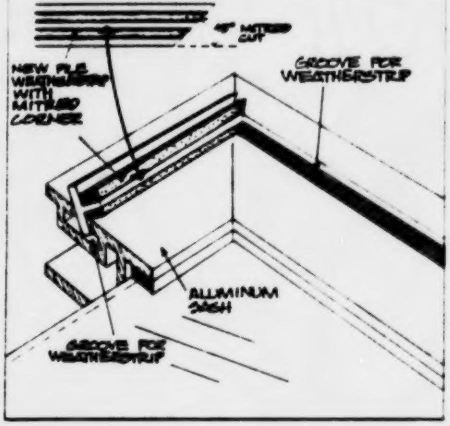
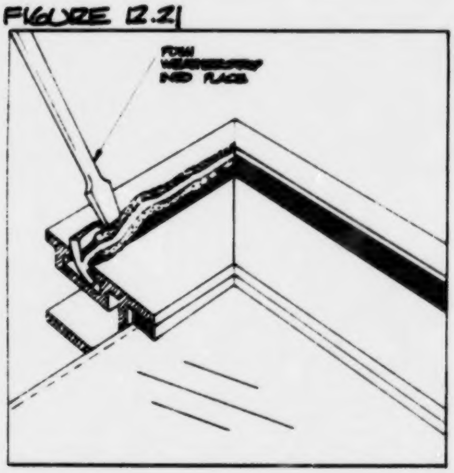

45° MITRED CUT
NEW PILE WEATHERSTRIP WITH MITRED CORNER
GROOVE FOR WEATHERSTRIP
ALUMINUM SASH
GROOVE FOR WEATHERSTRIP

FIGURE 12.21


FORM WEATHERSTRIP INTO PLACE

5. Replace the sliding unit in the track and check for ease of movement. If the slider does not move easily, the replacement pile may have the incorrect height

Procedure 2

REPLACING WEATHERSTRIPPING IN A SASHLESS SLIDING WINDOW

TOOLS

- Putty knife
- Wire brush
- Scraper

MATERIALS

- Mineral Spirits
- Weatherstripping: plastic "V" or self-adhesive pile
- Latex wood filler
- Clean white rags
- Sandpaper

(Additional tools and materials may be required if minor repairs are necessary)

This procedure shows how to replace deteriorated weatherstripping in the specific case of a sashless slider moving in a wood track. The techniques can be adapted for use with other sorts of sashless sliding windows.

The Procedure describes the use of plastic "V" weatherstripping. As an alternative, self-adhesive pile weatherstripping could be used. It should be applied in the same locations as recommended for the plastic "V" type. The pile height should be carefully selected to fit the window properly (allowing window movement but still sealing effectively).

PREPARATION

1. Remove sliding glass units.
2. Use a putty knife or other suitable tool to remove existing weatherstripping from the tracks and slider units, where applicable.
3. Using a wire brush and scraper, thoroughly clear loose paint, dirt, etc. from the tracks, wherever weatherstripping is to be applied (see below). Wipe the tracks with a rag soaked in mineral spirits.
4. If necessary, use latex wood filler and sandpaper to create a smooth surface for application of the weatherstrip.
5. On one of the slider units, use mineral spirits to clean the edge of the glass where weatherstripping is to be applied (see below).

PROCEDURE 2 (continued)
REPLACING WEATHERSTRIPPING IN A SASHLESS SLIDING WINDOW

APPLICATION

1. Identify the specific parts of the window frame to be weatherstripped. Weatherstripping is required in the tracks in the head jamb, side jamb and sill. For a window with two sliding units, this will involve the installation of six strips as illustrated in Figure 12.22.

   Note that it is only necessary to weatherstrip part of each of the tracks in the sill and head jamb - namely, the section of each track in which the glass sits when the window is closed.

2. Apply self-adhesive plastic "V" weatherstripping to the identified parts of the frame, as shown in Figure 12.23. The open side of the "V" should face towards the window frame. Care must be taken to cut the weatherstrip to a suitable length so as to ensure minimum gaps at corners.

3. In addition to the weatherstripping of the window frame, a vertical piece of self-adhesive plastic "V" weatherstrip should be applied to one of the slider units. This strip should be positioned where the two units overlap, as illustrated in Figure 12.24.

4. Re-install the glass sliders, and check to ensure that they still slide smoothly.

FIGURE 12.22

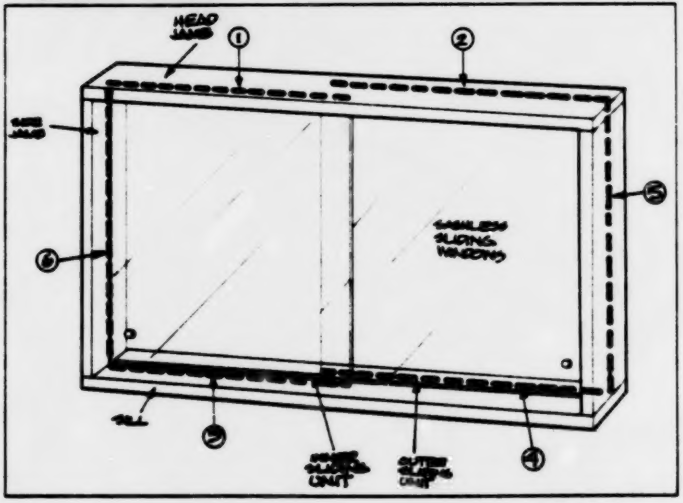


FIGURE 12.23

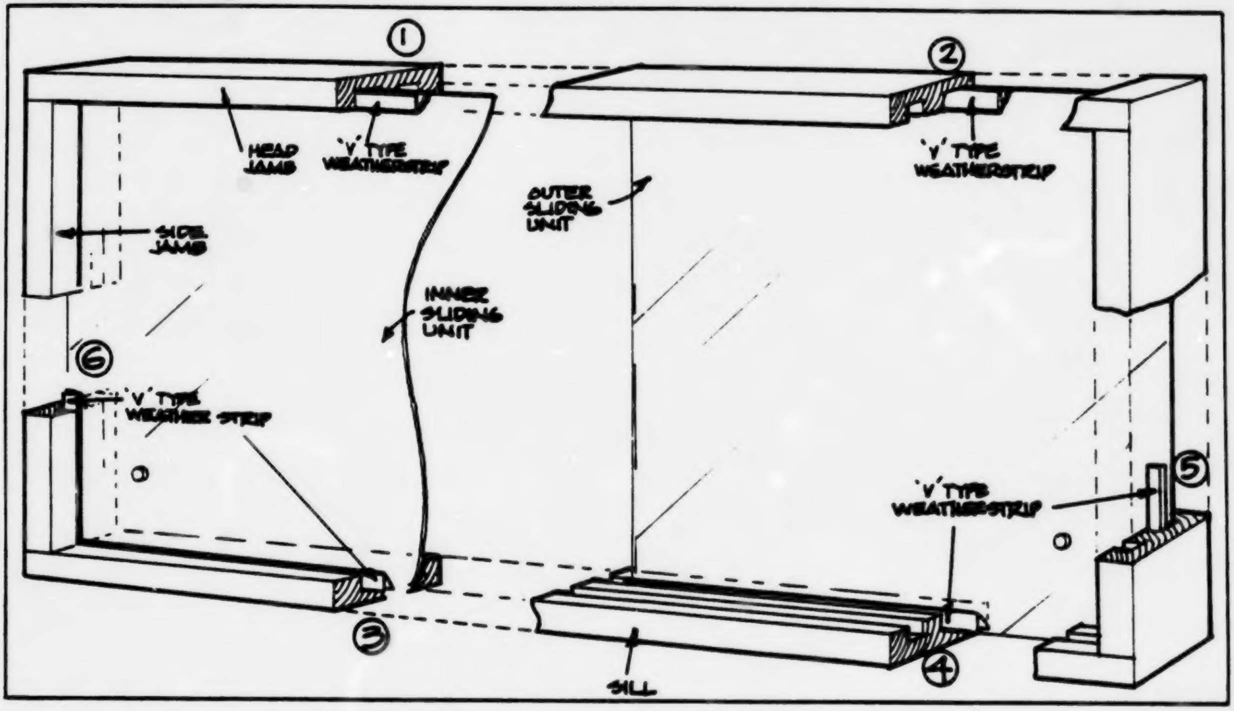
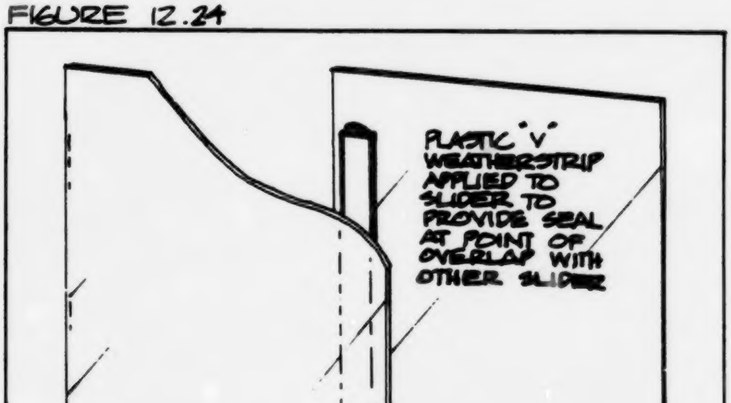

①
②
HEAD JAMB
'V' TYPE WEATHERSTRIP
'V' TYPE WEATHERSTRIP
OUTER SLIDING UNIT
SIDE JAMB
INNER SLIDING UNIT
⑥
'V' TYPE WEATHER STRIP
⑤
'V' TYPE WEATHERSTRIP
③
SILL
④

FIGURE 12.24


PLASTIC "V" WEATHERSTRIP APPLIED TO SLIDER TO PROVIDE SEAL AT POINT OF OVERLAP WITH OTHER SLIDER

Worksheet 5:
Additional procedures for hinged windows

INTRODUCTION

FIGURE 12.25 A

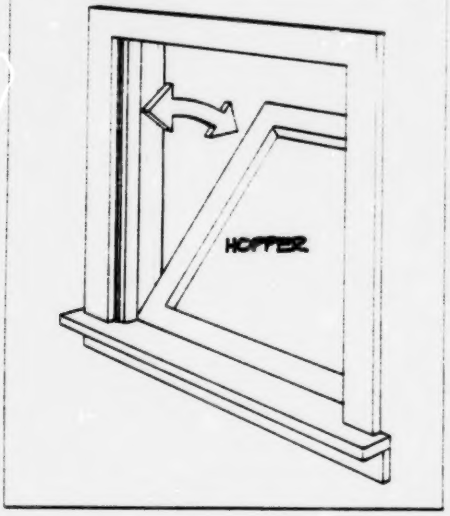


FIGURE 12.25 B

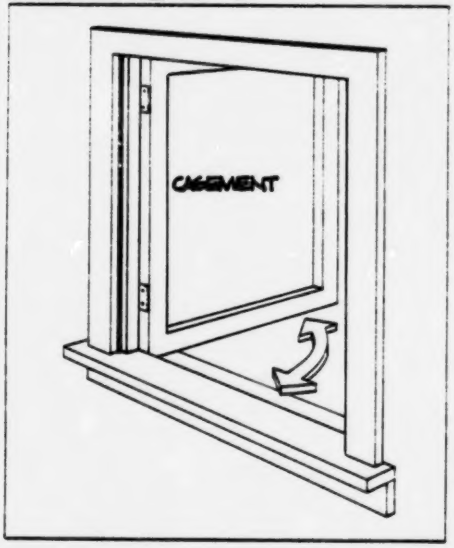


FIGURE 12.25C, OVER

There are three common types of hinged windows: casement, awning, and hopper. The three differ mainly in the location of the hinges, as shown in Figure 12.25.

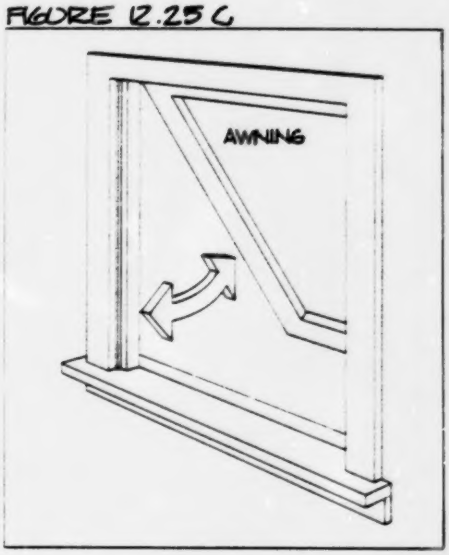
In addition to the types of air leakage dealt with by Windows: Worksheet 1, in hinged windows the problem of air leakage around the moveable sash must be addressed. This leakage can be considerable.

Casement, awning, and hopper windows generally have "operators" - cranks or levers that open and close the window. In all except the latest modifications, these mechanisms exert a very weak closing force. Consequently, if the unit is defective in any way, due to warping, worn weatherstripping, or hinge deterioration, the seal will be inadequate when the window is closed. In part to compensate, some units incorporate one or more sash locks which can pull the window tight for a better seal. However, in many cases the locks have deteriorated; in other cases, they are beneficial, but the number of locks is insufficient (as in the case of a single lock in a large window). Awning windows suffer from an additional problem: since the awning is suspended from the hinges, it may slump and become difficult to close properly.

In view of these considerations, the first step when dealing with air leakage around the sash of a hinged window is to examine the sash locks. **In the case of a window with large leakage gaps, considerable improvement in the window's tightness can often be achieved by adjusting or replacing ineffective locks and by installing additional ones on large windows).** Similarly, repair of other defective hardware (hinges, for instance) can, in some cases, reduce air leakage.

INTRODUCTION (continued)

FIGURE 12.25 C



If the window is inadequately weatherstripped, there will be a considerable air leakage problem, even after any upgrading of the sash locks. The necessary procedures to further seal the window are outlined in this Worksheet.

> **Procedure 1:** Techniques to weatherstrip a wood-framed hinged window.

The Procedure applies to all three types of hinged window. However, for ease of presentation, the description refers specifically to outward opening units. With inward opening units, the same general techniques should be used.

It should be noted that Procedure 1 deals exclusively with wood-framed windows. The techniques are generally applicable, with minor modification, to wood frame windows "clad" in vinyl. However, aluminum framed hinged windows require different techniques (more akin to the measures outlined in Windows: Worksheet 4, Procedure 1). Such windows are not common in residential construction; accordingly, no separate procedure is included in this edition of this Manual.

Procedure 1

WEATHERSTRIPPING A WOOD-FRAMED HINGED WINDOW

TOOLS

- Caulking gun
- Putty knife
- Scraper
- Wire brush
- Plane
- Stapler
- Tin snips or scissors
- Sandpaper
- Hammer
- Screwdriver

MATERIALS

- Mineral Spirits
- MEK (methyl ethyl ketone)
- 10 mm staples
- Latex wood filler
- Hardware as required
- Clean white rags
- Sealant: clear silicone
- Weatherstripping: narrow self-adhesive "V", high quality hollow tubular (or equivalent), or high quality plastic "V"

This Procedure outlines techniques for weatherstripping hinged, outward opening windows of the casement, awning, and hopper varieties.

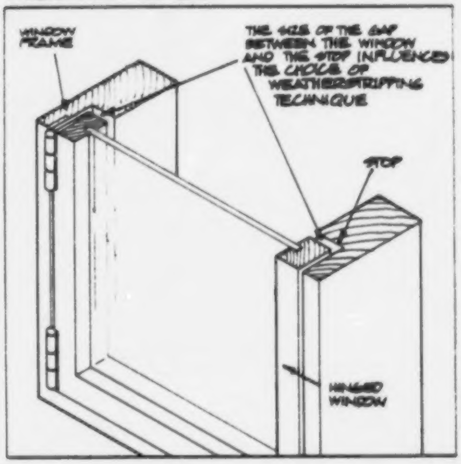
As has been mentioned in the Introduction to this Worksheet, considerable air leakage reduction can often be achieved through improvements to the sash locks (and other hardware). Beyond this, better weatherstripping is required in order to achieve further improvements. Generally, **if a window needs weatherstripping because the original seals have deteriorated, the best approach is to obtain and install matching replacement seals (if the original seals were effective).** This can often be done through the window manufacturer or through a weatherstripping supplier.

For other circumstances, this Procedure presents three groups of application techniques. The choice between the three is determined by the size of the gap between the sash and the stop, as illustrated in Figure 12.26.

One specific air leakage path is not addressed by these weatherstripping recommendations: air movement through the operator mechanism. If this is a problem, it may be possible to reduce it by sealing openings around the operator with silicone sealant (being careful not to impede the action of the operator). Also, in some cases the weatherstripping can be positioned so as to reduce this particular leakage problem. Contractors will need to respond to such situations on a case-by-case basis.

PROCEDURE 1 (continued)
WEATHERSTRIPPING A WOOD-FRAMED HINGED WINDOW

FIGURE 12.26


WINDOW FRAME
THE SIZE OF THE GAP BETWEEN THE WINDOW AND THE STOP INFLUENCES THE CHOICE OF WEATHERSTRIPPING TECHNIQUE
STOP
HINGED WINDOW

PREPARATION

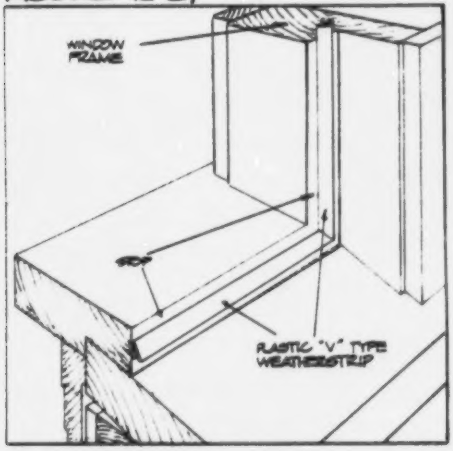
1. Remove old weatherstripping from the window.

2. Scrape loose paint and dirt from surfaces that will be in contact with the new weatherstripping.

3. Using latex wood filler, fill indentations in surfaces where weatherstripping is to be applied, and allow to dry. Sand to smooth the surface. If necessary, plane any further surface irregularities.

4. Wipe the surfaces to be weatherstripped with mineral spirits or MEK.

FIGURE 12.27


WINDOW FRAME
STOP
PLASTIC "V" TYPE WEATHERSTRIP

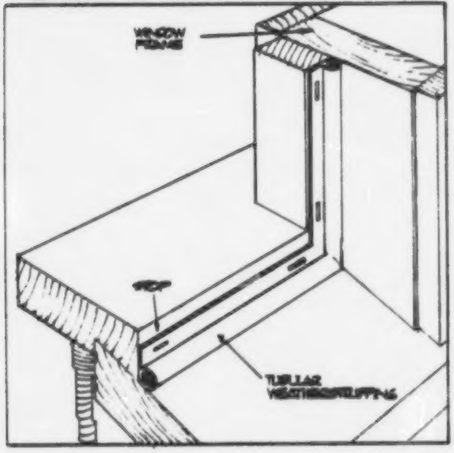
APPLICATION: Gaps of 4.0 mm or less

1. Install self-adhesive narrow plastic "V" weatherstripping. This should be applied to the window stop on all sides of the window, with the open part of the "V" pointing towards the window frame. See Figure 12.27.

2. At corners, cut the ends of the weatherstripping at an angle to allow for a tight fit and a continuous seal.

3. To reinforce the adhesive strip, staple at approximately 150 mm intervals. Hammer the staples flush.

FIGURE 12.28


WINDOW FRAME
STOP
TUBULAR WEATHERSTRIPPING

APPLICATION: Gaps of 4.0 to 8.0 mm

1. Apply tubular weatherstripping to the stop on all sides of the window, as shown in Figure 12.28. The weatherstrip is attached with staples through its flange, at a spacing of 150 mm. Hammer the staples flush.

WINDOWS:
WORKSHEET 5
continued

PROCEDURE 1 (continued)
WEATHERSTRIPPING A WOOD-FRAMED HINGED WINDOW

FIGURE 12.29

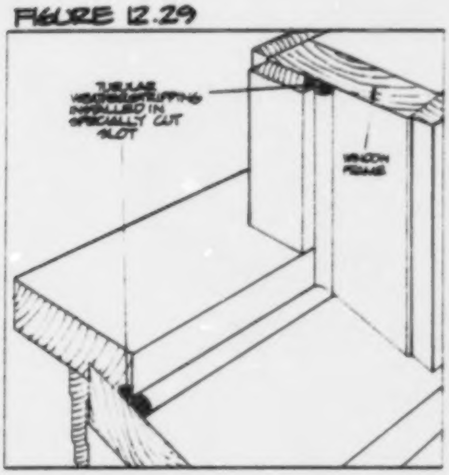


FIGURE 12.30

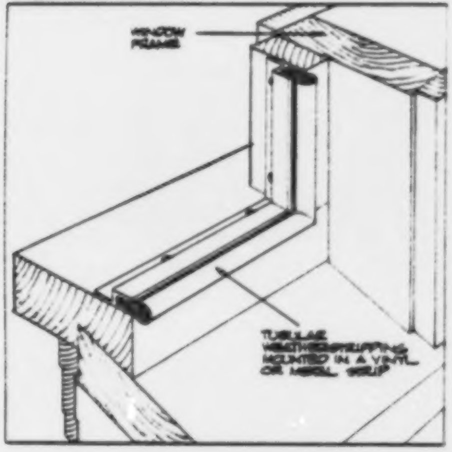
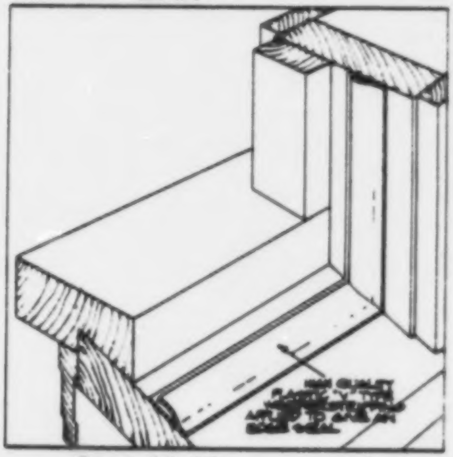


FIGURE 12.31



2. If a small diameter of tubular weatherstripping is being used, it can be run around the frame in one piece, without cutting at corners. If a larger diameter is used, the weatherstrip will need to be mitred at the corners (i.e. both converging strips should be cut at a 45° angle) in order to provide a good, continuous seal.

3. Alternatively, the tubular weatherstrip can be installed by inserting the flange into a specially-cut slot in the window stop. This should only be done when such a slot already exists. In such cases, the result is a neat and effective seal, as shown in Figure 12.29.

4. A third option is to use tubular weatherstripping, mounted in a vinyl or metal attachment strip. This should be installed with screws, as shown in Figure 12.30. The corner should be mitred.

5. In all cases, sealant should be applied at the corners of the weatherstripping, in order to provide a continuous seal. Clear silicone is the best option.

APPLICATION: Gaps greater than 8.0 mm

1. Install, high quality, wide plastic "V" weatherstripping on the frame so that it makes contact with the edge of the sash, as shown in Figure 12.31. (See Chapter 13, Worksheet 2 for a discussion of the advantages of edge seals.) The open part of the "V" should face inwards. Staple every 150 mm.

2. At the corners, trim the weatherstripping, on an angle, in order to provide a neat, continuous seal.

Worksheet 6:
Additional procedures for storm windows

INTRODUCTION

Many window units are equipped with removeable storm windows that are intended to improve the "thermal performance" of the overall unit. In such cases, in addition to the air sealing measures identified in Windows: Worksheets 1-5 it may be necessary to address air leakage around the storm window.

This Worksheet considers air-sealing techniques for three major types of storm windows:

Procedure 1: Techniques to weatherstrip exterior wood-sashed storm windows.

Procedure 2: Techniques to weatherstrip and seal exterior metal-sashed storm windows.

Procedure 3: Techniques to seal part-window storms (interior or exterior)

(Part-window storms are usually glass in an aluminum framework. The unit attaches to the sash of the main window, rather than to the window frame. Unlike whole-window storms, which attach to the frame, these part storms do little to cut air leakage through the window.)

A fourth type of storm window has become common in recent years. Whole-window interior storms are now widely used as retrofit measures to reduce drafts and heat loss through windows. If properly installed, most of these windows should not be a significant source of air leakage. As such, no sealing procedures are presented here.

A cautionary note

A good rule, when dealing with storm windows, is to ensure that the inner (warm side) window unit is always more tightly sealed than the outer. In particular, in the case of exterior whole-window storms, the main window should be better sealed than the storm. Otherwise, moist house air will exfiltrate into the space between the main window and the storm where it will be trapped. The result will be condensation build-up on the storm.

The same principle applies to part-window exterior storms. If the inner, permanent pane of glass is poorly sealed or has defective glass-to-sash sealing, condensation build-up can occur if the storm is reasonably airtight. Similarly, in the case of interior storms, if highly effective sealing or weatherstripping techniques are applied to the main window units, these may become more airtight than the interior storms, resulting in condensation on the outer window.

Though the general principle applies to all storms and should always be respected, from a practical point of view it is the exterior whole-window units where problems are most likely to occur.

There are no established guidelines on how tightly or how loosely to seal such a storm. In general, it is recommended that if exterior storms are weatherstripped, the seal should be slightly imperfect. Also, as a further precaution, it is recommended that the main window units be properly sealed or weatherstripped before any attempt is made to weatherstrip the storm unit.

WINDOWS:
WORKSHEET 6
continued

Procedure 1

WEATHERSTRIPPING EXTERIOR WOOD-SASHED STORM WINDOWS

TOOLS

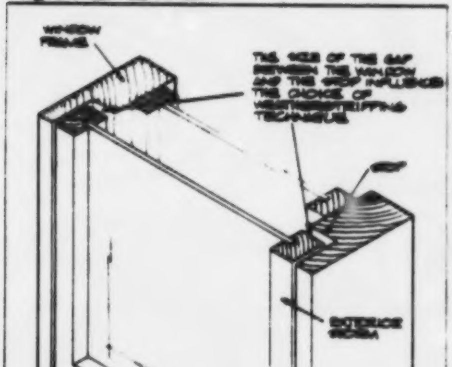
- Putty knife
- Wire brush
- Scraper
- Plane
- Stapler
- Tin snips or scissors
- Sandpaper
- Screwdriver

MATERIALS

- Mineral Spirits
- 10 mm staples
- Weatherstripping: narrow self-adhesive plastic "V", and/or hollow tublar, and/or door sweep (depending on the job)
- Clean white rags
- Latex wood filler

(Additional tools and materials may be required if minor repairs necessary)

FIGURE 12.32


WINDOW FRAME
THE SIZE OF THE GAP BETWEEN THE WINDOW AND THE STOP INFLUENCES THE CHOICE OF WEATHERSTRIPPING TECHNIQUE
STOP
EXTERIOR STORM

This Procedure discusses techniques for weatherstripping exterior wood-frame storms. It is inadvisable to conduct this work unless the main window unit is made airtight first.

Three alternative techniques are presented. The choice between the three is determined by the size of the gap between the storm windows and the stop (as shown in Figure 12.32) and by the amount of warping the window displays. Large storms may display a great deal of warpage.

As discussed in the introduction to this Worksheet, it is usually not desirable to achieve a "perfect" seal around a storm window, since this may trap moisture. Accordingly, in each of the three techniques presented here, **small gaps in the weatherstripping can be left at each corner.**

Storm windows are often in poor condition. Before weatherstripping therefore, air leakage through the storm should be stopped. Specifically, cracks in the sash and ineffective glass-to-sash seals should be dealt with, as outlined in Windows: Worksheet 1 (Procedures 3 and 4).

PREPARATION

1. Remove the storm unit.

2. Remove any old weatherstripping material.

PROCEDURE 1 (continued)
WEATHERSTRIPPING EXTERIOR WOOD-SASHED STORM DOORS

3. Use a plane and scraper to prepare smooth wood surfaces where the weatherstripping is to be applied. If necessary, fill indentations with latex wood filler and sand smooth.

4. Clean surfaces to be weatherstripped with a wire brush, rags, and mineral spirits.

APPLICATION: Small gaps, no significant warping

(See Figure 12.33)

1. Install narrow self-adhesive plastic "V" weatherstripping on the stops at the head jamb and side jambs of the window frame. The weatherstripping should be installed with the open part of the "V" facing the jambs, so that it makes a compression seal when the storm window is closed.

2. If the sill has a stop, the same technique can be applied along the sill stop. But if the sill has no stop, the plastic "V" should be installed on the bottom edge of the storm window, with the open part of the "V" facing the house interior.

3. Staple all plastic "V" weatherstripping at approximately 150 mm intervals.

4. Re-install the window.

APPLICATION: 4 to 8 mm gaps, moderately large warping

1. Install hollow tubular weatherstripping on the stops at the head jamb and side jambs of the window frame. This should provide a compression seal when the storm window is in position. Staple at 150 mm intervals.

FIGURE 12.33 A

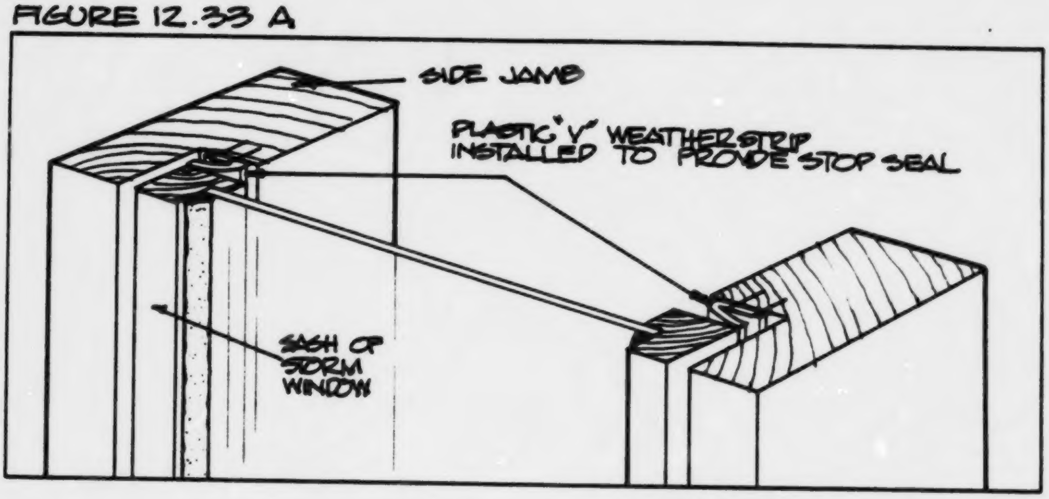

SIDE JAMB
PLASTIC "V" WEATHERSTRIP INSTALLED TO PROVIDE STOP SEAL
SASH OF STORM WINDOW

FIGURE 12.33 B

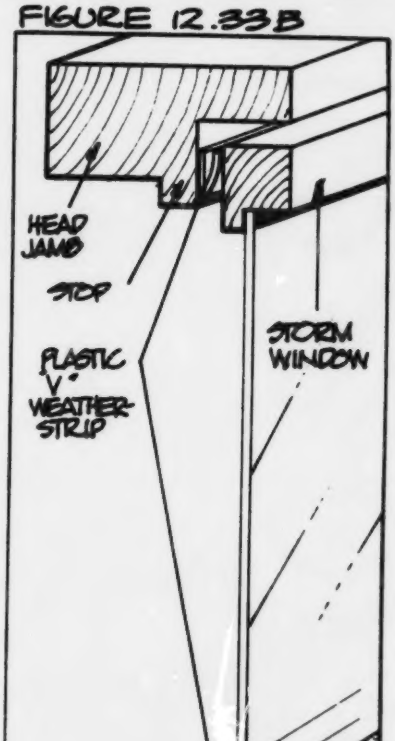
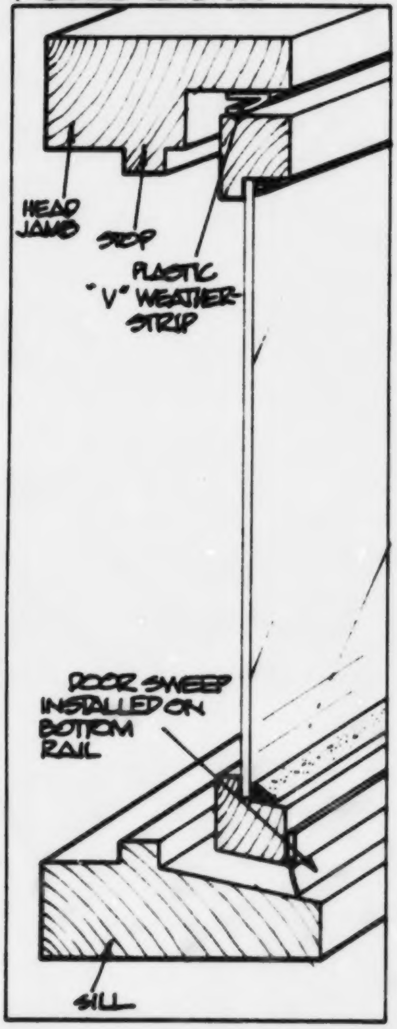

HEAD JAMB
STOP
PLASTIC "V" WEATHER-STRIP
STORM WINDOW
SILL

FIGURE 12.34A


HEAD JAMB
STOP
PLASTIC "V" WEATHER-STRIP
DOOR SWEEP INSTALLED ON BOTTOM RAIL
SILL

2. Install hollow tubular weatherstripping with a vinyl or metal flange along the bottom edge of the storm window. Alternatively, install a door sweep on the bottom rail of the storm sash.

3. Re-install the window.

APPLICATION: Large gaps and large warping

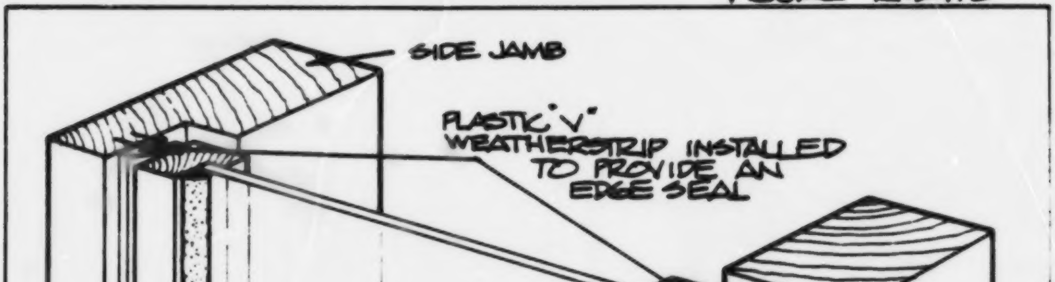
(See Figure 12.34)

1. Install self-adhesive plastic "V" weatherstripping on the head jamb and side jambs of the window frame, so that the weatherstripping makes an edge seal around the storm. (See Chapter 13, Worksheet 2 for a discussion of the advantages of edge seals.) The open part of the "V" should face the house interior. Staple the weatherstripping at 150 mm intervals.

2. Install a door sweep on the bottom rail of the storm sash.

3. Re-install the storm window.

FIGURE 12.34.B


SIDE JAMB
PLASTIC "V" WEATHERSTRIP INSTALLED TO PROVIDE AN EDGE SEAL
SASH OF STORM WINDOW

Procedure 2

WEATHERSTRIPPING AND SEALING EXTERIOR METAL-SASHED STORM WINDOWS

TOOLS

- Screwdriver
- Putty knife
- Caulking gun
- Brush
- Scraper
- Sandpaper

MATERIALS

- MEK (methyl ethyl ketone)
- Clean white rags
- Sealant: Acrylic, coloured to match
- Latex wood filler
- Vinegar
- Storm window seals to match original

(Additional tools and materials may be required if minor repairs necessary)

This Procedure outlines techniques for weatherstripping and sealing metal storm windows. Specifically, it outlines an approach for those metal storm windows that are provided with their own storm frame. The frame is usually mounted on the trim around the main window. (For other metal storms that are simply mounted directly into a wood frame, weatherstripping work would involve replacement of deteriorated original seals, if any and if effective. Otherwise, such storms can be sealed by adapting the techniques outlined in Procedure 1 of this Worksheet.)

This work should not be conducted unless the main window unit has first been sealed.

Because of the possibility of trapping moisture between the storm and main windows, it is not advisable to achieve a "perfect" seal when weatherstripping any exterior storm window.

PREPARATION

1. Remove the storm sash and, if not too difficult, the separate storm frame mounted on the trim around the main window.

2. Ensure that the surface where the frame is to be re-installed is relatively smooth. If necessary, use a scraper, latex wood filler, and sandpaper to even the surface.

3. Use a brush, MEK, and clean white rags to clean all wood surfaces to which sealant will be applied.

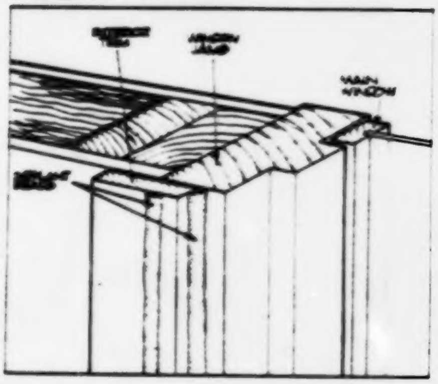
4. Clean the face of the storm frame that will be pressed against the sealant. Rub the surface with an etching solution such as vinegar. Prime if required by the sealant manufacturer.

PROCEDURE 2 (continued)
WEATHERSTRIPPING AND SEALING EXTERIOR METAL-SASHED STORM WINDOWS

APPLICATION

1. If the existing weatherstripping on the storm window has deteriorated, install matching replacement seals, if available. Commonly, the original seals will be a type of pile weatherstripping. If so, refer to Windows: Worksheet 4, Procedure 1 for replacement techniques.

FIGURE 12.35



2. Apply a continuous bead of sealant at the joint of the exterior window trim and the window frame, as shown in Figure 12.35.

3. Apply a second continuous bead of sealant on the exterior face of the trim, exactly where the storm frame is to be re-installed.

4. Re-install the storm frame and remove any excess sealant.

5. Re-install the storm.

Procedure 3

SEALING PART-WINDOW STORMS (INTERIOR OR EXTERIOR)

TOOLS

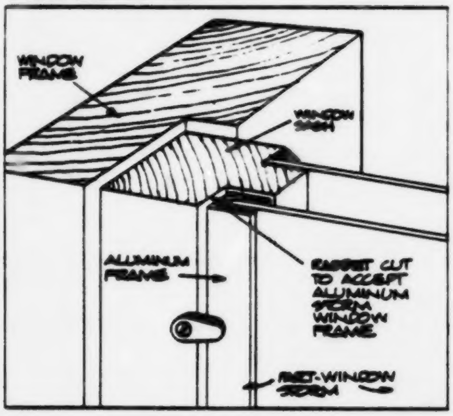
- Knife
- Putty knife
- Scraper
- Screwdriver
- Caulking gun

MATERIALS

- Sealant: oil or resin based caulk
- MEK (methyl ethyl ketone)
- Vinegar
- Window cleaner
- Clean white rags
- Primer, if required

(Additional tools and materials may be required if minor repairs necessary)

FIGURE 12.36



This Procedure outlines techniques for sealing interior or exterior part-window storms. These are aluminum-framed panes of glass that sit in a notch (known as a rabbett) in the sash of a regular window. See Figure 12.36

PREPARATION

1. Remove the storm window. In the case of units that are not routinely removed, this may require use of a knife to score the paint along joints (so as to avoid paint flaking and peeling).

2. Use a scraper to prepare a clean smooth surface inside the rabbett (notch). Wipe with MEK. Prime the surface if required by the sealant manufacturer.

3. Remove dirt, grease, paint, etc. from the aluminum frame. Prepare the surface to be sealed with an etching solution such as vinegar.

4. Clean the inward-facing sides of the storm and main windows. (These will be inaccessible for cleaning when the sealing job is completed).

APPLICATION

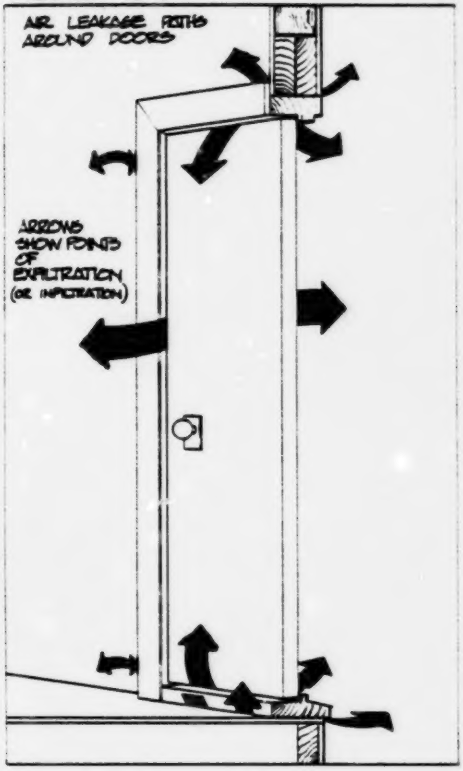
1. Apply a fine continuous bead of oil or resin based caulk in the rabbett.

2. Insert the storm window unit, and fix it in place using the existing fasteners. If necessary, install new fasteners to hold the window firmly against the sealant bead.

Chapter 13:
Doors

INTRODUCTION

FIGURE 13.1


AIR LEAKAGE PATHS AROUND DOORS
ARROWS SHOW POINTS OF EXFILTRATION (OR INFILTRATION)

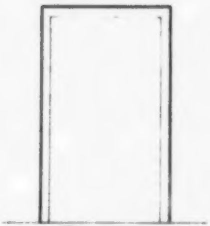
There are many channels for air leakage through and around doors, as illustrated in Figure 13.1. This chapter describes the recommended sealing and weatherstripping techniques for the common door types.

Note: In some older houses, the doors might be in poor condition, or might be unsuited to use as an exterior door. In such cases, heat loss through the door can be considerable, even if the effects of air leakage are ignored. This chapter is not concerned with the insulating properties of doors, but sealing contractors should be aware that it might sometimes be advisable to replace door units, either for rehabilitation or as an energy conservation measure.

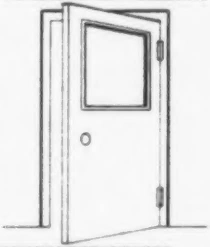
For definitions of specialized door terminology, refer to the glossary at the end of this Manual.

GUIDE TO THE WORKSHEETS

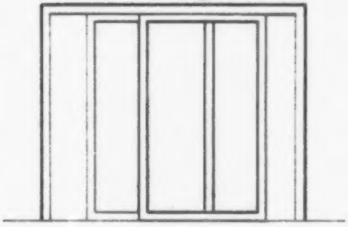
The following pages contain 4 Worksheets, each concerned with a different aspect of door sealing/weatherstripping. The Worksheets provide step-by-step guidance on the following topics:



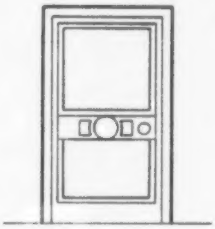
Procedures applicable to most **DOORS** . . . . . . Worksheet 1



Additional procedures for **HINGED DOORS** . . . . . . Worksheet 2



Additional procedures for **SLIDING DOORS** . . . . . . Worksheet 3



Additional procedures for **STORM DOORS** . . . . . . Worksheet 4

For each specific procedure described in each Worksheet, preparation and application requirements are described, step by step. In addition, the necessary tools and materials are identified in each case.

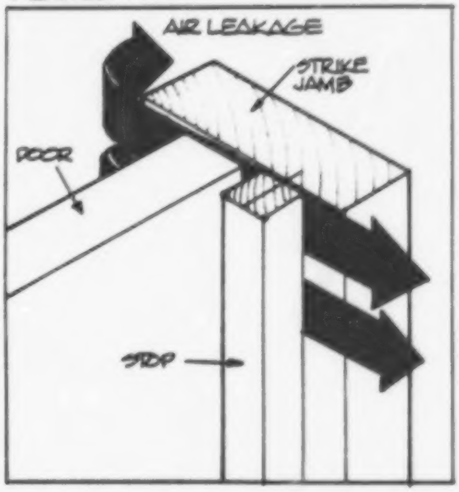
For most door sealing jobs, it will be necessary to refer to two Worksheets: Worksheet 1 (for common procedures) plus one other (for additional procedures specific to the door type).

Worksheet 1:
Procedures applicable to most doors

INTRODUCTION:

This Worksheet considers two points of air leakage that are common to a great many doors, regardless of the type of door:

FIGURE 13.2



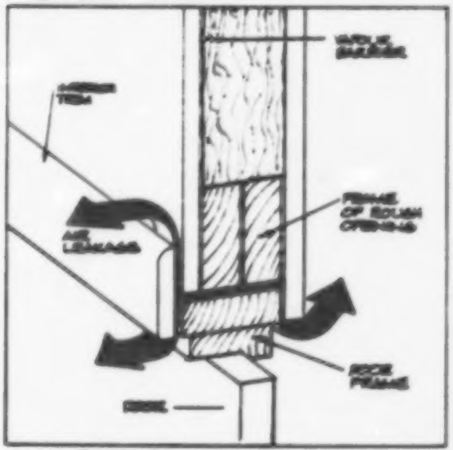
Air leakage through the door frame

Over the years, structural joints in a wood door frame may tend to open up, allowing air leakage. In most frames, these joints occur only at the corners, where the side jambs meet the head jamb and sill.

In some doors, there is an additional leakage path where the door stops are nailed,screwed or glued to the jamb (see Figure 13.2). More commonly, however, the stops are an integral part of the jambs (see Figure 13.5 for instance) and so do not provide an air leakage path.

The sealing of any gaps in the door frame, whether at the corners or behind the stops, can be accomplished in the same general fashion as has been outlined for window frames. Accordingly, no additional procedure is presented here. Contractors should refer to Windows: Worksheet 1 (Procedure 3) for guidance on proper techniques.

FIGURE 13.3



Air leakage between door frame and wall

Doors are set into rough openings in the wall frame. There is usually a considerable gap, up to 20 mm wide, between the door frame and the surrounding wall. This gap is normally concealed by the interior door trim, but may nevertheless be responsible for a large amount of air leakage (see Figure 13.3). Even if the gap is filled with insulation, air leakage can be significant, since most types of insulation do little to stop air movement. Similarly, the wall vapour barrier (if any) has little effect on air leakage around the door frame, since it usually terminates at the rough opening.

The gap between the door frame and the surrounding wall is similar in many respects to the gap around windows, and can be sealed in much the same way. However, the door frame is subjected to a great deal of vibration from repeated opening and closing of the door. The sealing technique should therefore be capable of withstanding this vibration. This has two consequences:

- A more limited range of high quality sealants are recommended for door sealing than for window sealing. At the door sill, the sealant should have good elastic and compression properties. Around the frame, it should have good shear properties.

- In windows, two sealing techniques are available: sealing around the trim without removing it, and sealing behind the trim. In doors, the first approach is not a reliable vibration-resistant technique. It is therefore recommended that only the second approach (trim removal) be utilized in the case of doors.

This Worksheet provides detail on the recommended approach:

Procedure 1: Techniques to seal behind the interior door trim.

In addition to the common techniques noted in this Worksheet, the proper sealing of any door requires the use of additional techniques, as outlined for each of the various door types in Doors: Worksheets 2-4.

DOORS:
WORKSHEET 1
continued

Procedure 1

SEALING BEHIND THE INTERIOR DOOR TRIM

TOOLS

- Pry bar
- Knife
- Nail punch
- Caulking gun
- Staple gun
- Utility Knife
- Scissors
- Scraper
- Hammer

MATERIALS

- Sealant for side jambs and head: silicone
- Sealant for sill: paintable silicone
- Sealant for use with polyethylene: high solids butyl rubber or acoustical sealant
- MEK (methyl ethyl ketone)
- Backer rod
- Clean white rags
- Glass fibre or mineral fibre insulation
- 0.150 mm polyethylene
- Primer, if required

(Additional tools and materials may be required if minor repairs are necessary).

This Procedure outlines techniques for removing trim around doors and sealing the gap between the door frame and the surrounding wall and floor.

PREPARATION

1. Where necessary, score the trim paint with a knife, in order to prevent paint from chipping and peeling when the trim is removed.

2. Remove the trim using pry bar. A piece of plywood should be used as a leverage surface for the pry bar to eliminate damage to the surrounding wall. Nails that resist removal can be punched through using a nail punch. After trim removal, any residual nails should be removed.

3. Inspect the gaps around the door frame. Where there are large, uninsulated gaps, work insulation into the gaps but do not compress. If the gap is greater than 25mm, urethane foam insulation may be used (if care is taken to allow for expansion of the foam).

4. Using MEK, clean the frame, surrounding wall, and floor around the sill, to remove dirt and grease. Remove any excess paint with a scraper. Prime if required, following the sealant manufacturer's instructions.

APPLICATION

1. Seal the gap along the head and side jambs, using one or more of the following techniques:

- Where the gap between the frame and wall is less than 3mm, seal by applying a bead of silicone sealant to fill the gap

PROCEDURE 1 (continued)
SEALING BEHIND THE INTERIOR DOOR TRIM

- Where the gap is 3mm to 6 mm wide, insert a backer rod into the gap, to a depth not greater than 6mm. Then apply silicone sealant against the backing rod so as to make a good seal between the frame and wall

- Where the gap is wider than 6mm, it should be sealed with strips of 0.150mm polyethylene. The strip should be attached by running a bead of the acoustical or high solids butyl rubber sealants along both the door frame and the wall. Press the polyethylene strips into the sealant and staple every 150mm. Hammer the staples flush.

2. Inspect the seals. If the door has been sealed using more than one of the above options, make sure the seal is continuous where the techniques change.

3. Seal the gap between the sill and the floor with paintable silicone sealant. Make sure that this is worked well into the gap. Carry the sealant bead around the ends of the sill to make a continuous sealed joint with the previous work around the jambs. (In conjunction with this work, the sealing of leakage points through the frame can be carried out. See the introduction to this Worksheet for details).

4. Re-install the trim. Remove any protruding polythylene or excess sealant.

Worksheet 2:
Additional procedures for hinged doors

INTRODUCTION:

Hinged doors constructed of wood or metal are the most common exterior door types. **In addition to the types of air leakage dealt with by Doors: Worksheet 1**, in hinged doors the problem of air leakage through and around the door must be dealt with.

Leakage through the door

Depending upon the age and construction of the door, there are a number of potential paths for air leakage through it. For instance, loose structural joints in a wood door and improper sealing of any glass panels will both allow leakage. These problems can be dealt with by following the steps outlined in Windows: Worksheet 1 (Procedures 3 and 4 respectively). Accordingly, no additional procedures are identified in this Worksheet.

Other leakage can be associated with door hardware. Typical hardware leakage points include the mail slot, door knob, and lock. No specific guidance is given in this manual on these problems. Experienced contractors will be able to devise their own techniques for dealing with small, job-specific, problems of this type.

Leakage around the door

Air leakage between the door and door frame is usually the main source of air leakage in door units. There are several causes of gaps between the door and the frame:

- Poor installation of the door
- Distortion of the door frame due to house movement or warping

INTRODUCTION (continued)

- Warping of the doors themselves due to temperature and moisture effects
- Poor or non-existent door seals.

As a result of these various factors, the width of the air gap may vary considerably around a door. At some points it may be a hairline crack and at others it may be as large as 10mm. What is more, the processes of warping and settling will probably continue indefinitely, and the gap pattern around any given door may vary considerably from season-to-season and year-to-year.

These difficult characteristics are further complicated by the fact that doors typically receive heavy use. This means that any seal must be durable, but at the same time must not impede use of the door.

Clearly, the selection of the proper type of weatherstripping is of great importance. Unfortunately, there are so many different types available that it is difficult to make the right choice.

In view of the importance of this choice, Procedure 1 of this Worksheet is concerned solely with the selection of weatherstripping, not with step-by-step application:

> **Procedure** 1: Selection of weatherstripping type for the sealing of hinged doors.

The type(s) of weatherstripping selected will determine the application procedures: there is no one general procedure that can be spelled out in this manual. The preparatory steps (necessary before any type of weatherstripping can be applied) are, however, broadly common to most types of door seal. Similarly, certain application measures have general relevance. This Worksheet outlines these various common steps:

INTRODUCTION (continued)

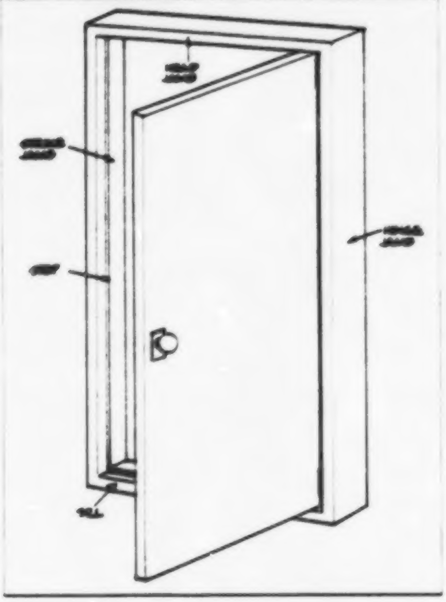
Procedure 2: General techniques associated with door weatherstripping.

It should be emphasized that Procedure 2 does not provide complete, step-by-step application instructions. **The techniques described are just a starting point. More precise and complete instructions should normally be available from the manufacturer of the chosen seal(s).**

Procedure 1

SELECTION OF WEATHERSTRIPPING TYPE FOR THE SEALING OF HINGED DOORS

FIGURE 13.4



This Procedure reviews the major factors that must be taken into account when selecting appropriate seals for each "weatherstrippable" part of the door (the strike jamb, head jamb, hinge jamb, and sill, as shown in Figure 13.4).

These factors should be considered in conjunction with the information on weatherstripping materials presented in Chapter 7 and Appendix 2 of this manual.

Before reviewing each location individually, the following general points should be considered:

- Many metal thermal door designs are fitted with custom-made weatherstripping. If possible, in such cases, it is preferable to obtain matching new seals from the manufacturer when conducting re-sealing work.
- In some cases, wood doors may have seals that are set into the jamb in a special way, such as plastic weatherstripping that is set into a slot in the jamb. In such instances the contractor should consider using replacement seals of the same type, if available. First, make sure that the weatherstripping meets the criteria noted below
- As has been noted, the width of the gap between any given door and its frame varies from point-to-point and season-to-season. Therefore, when selecting new seals, **preference should be given to those types which can accommodate large changes in gap width (as much as 5mm) over a period of years**
- The majority of seals are made of various types of plastic, rubber, or metal, and rely on the resilience (or springiness) of these materials to provide a seal with the door. However, some

of these materials lose their springiness when exposed to low temperatures. When this happens, the materials may become relatively rigid, and their sealing effectiveness may be impaired. Therefore, **the ability to tolerate low temperatures is an important requirement** in seal selection (particularly in northern locations)

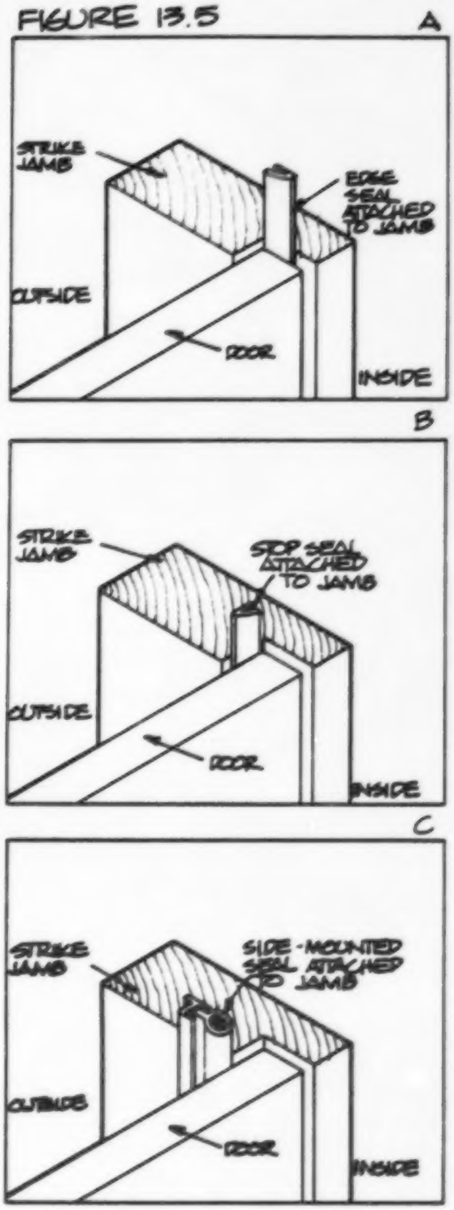
Door weatherstripping works either by compression (e.g. hollow tubular seals) or by bending (e.g. plastic 'V' seals). It is relatively easy to compress or bend a small section of seal. However, around a door there is usually a total length of about 6 metres of weatherstripping. To close the door against the action of this length of seal, extra force is required. **The type of seal should be selected so that excessive closing force is not required.**

Beyond these general factors, a variety of factors related to location must be considered:

Selection of Seals for the Strike Jamb

For convenience, the options for positioning weatherstripping at the strike jamb can be divided into three categories: edge seals, stop seals, and side-mounted seals, as illustrated in Figure 13.5.

FIGURE 13.5

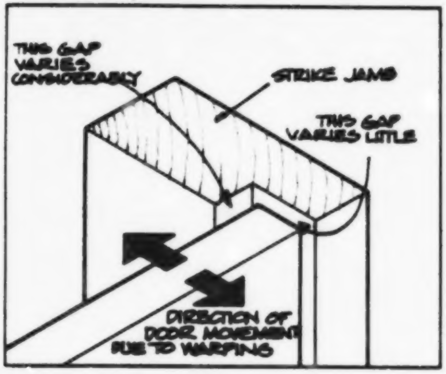


To understand the relative merits of these options, one fact should be noted. The side of the door opposite the hinges tends to experience more warpage than other parts of the door (because of its length and the fact that it is not attached to the frame). Therefore, when the door is closed, the gap between the door and the stop may vary considerably from top to bottom, and will also vary from season to season. In contrast, this warping has relatively little effect on the gap between the door edge and the jamb (see Figure 13.6). Therefore:

PROCEDURE 1 (continued)

SELECTION OF WEATHERSTRIPPING TYPE FOR THE SEALING OF HINGED DOORS

FIGURE 13.6


THIS GAP VARIES CONSIDERABLY
STRIKE JAMB
THIS GAP VARIES LITTLE
DIRECTION OF DOOR MOVEMENT DUE TO WARPING

- Edge seals are generally the best option for weatherstripping at the strike jamb. Their effectiveness is not impaired by warping of the door. They do not require much closing force, and, being installed close to the inside of the house, they are not exposed to the worst climatic temperature effects. However, they must be interrupted at the lock set

- Stop seals must be able to accommodate a wide gap variation. They must have a wide compressible range, which means that the required door closing force is relatively high. They are relatively exposed to exterior temperatures

- Side mounted seals must also be able to accommodate a wide gap variation. In some designs this is achieved with spring loading, which allows movement of the seal up to about 6mm. Side-mounted seals have major exposure to exterior temperatures.

Note that some manufacturers offer special mouldings which give both an edge seal and a stop seal. These are marginally better than edge seals, since they also give a good seal around the lock set.

Selection of seals for the head jamb

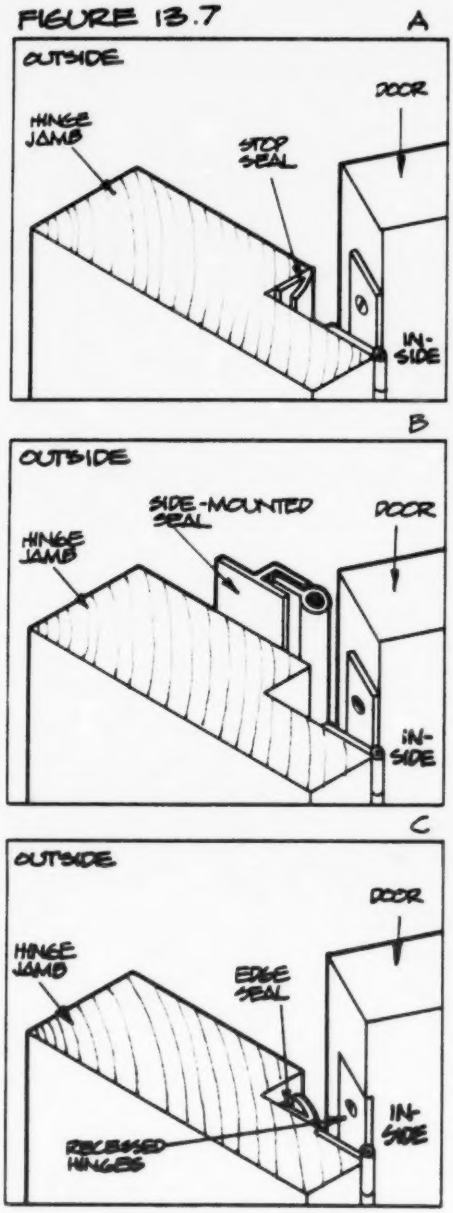
The requirements at the head jamb are the same as for the strike jamb, though the range of the gap width may be less severe. Where possible, the same seals should be used on the head jamb as on the strike jamb.

Selection of seals for the hinge jamb

The door hinges help to resist warping of the door along the hinge edge. As a result, the air gap along this edge is usually small and displays

SELECTION OF WEATHERSTRIPPING TYPE FOR THE SEALING OF HINGED DOORS

FIGURE 13.7


A
OUTSIDE
DOOR
HINGE JAMB
STOP SEAL
IN-SIDE
B
OUTSIDE
SIDE-MOUNTED SEAL
DOOR
HINGE JAMB
IN-SIDE
C
OUTSIDE
DOOR
HINGE JAMB
EDGE SEAL
IN-SIDE
RECESSED HINGES

limited variation in width. Therefore, though the same three sealing options exist as in the case of the strike jamb (see Figure 13.7), the acceptability of the options changes:

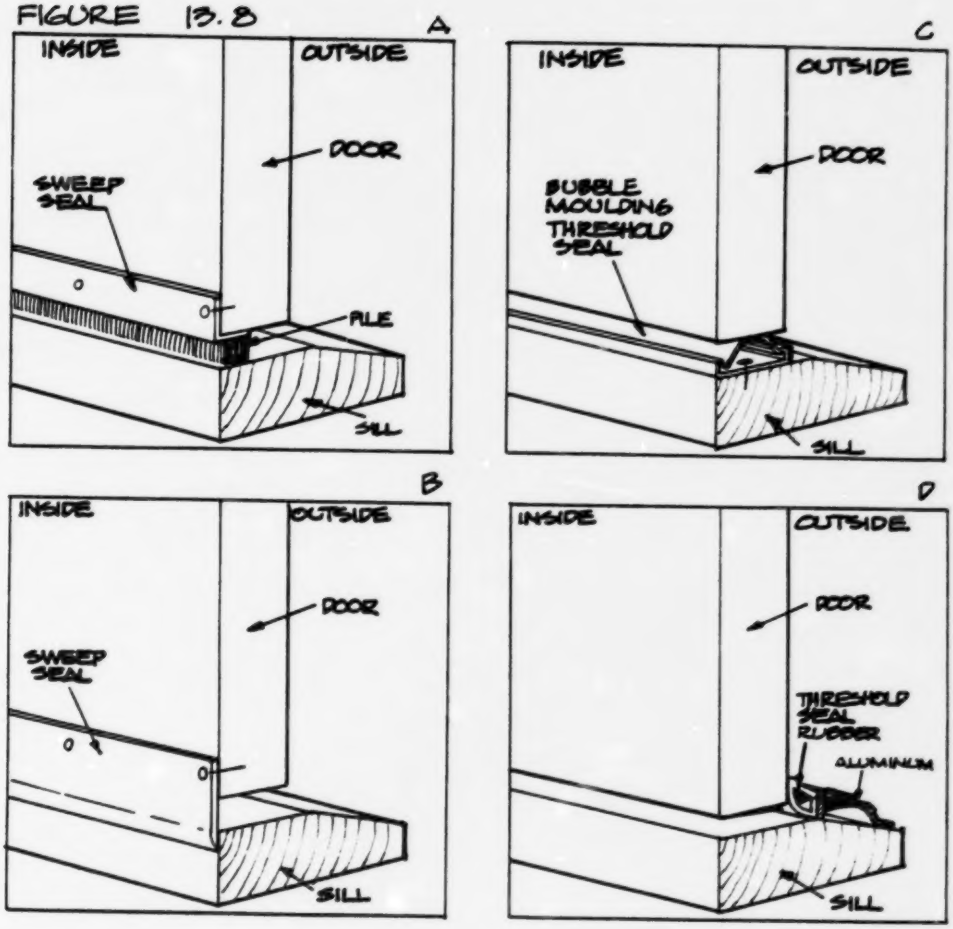
- Stop seals are a good option, because of the relatively narrow and uniform gaps along the edge. Self adhesive plastic 'V' weatherstrip is a suitable material to use.
- Edge seals are also a good option, provided that the hinges are properly recessed into the jamb.
- Side mounted seals require care in installation and positioning, since the seal may become trapped or damaged by the closing door.

Selection of seals for the sill

Sill seals can be divided into two main categories: "sweeps", which are attached to the bottom of the door and "threshold seals", which are attached to the door sill. Figure 13.8 provides examples of both types.

Contractors should refer to Chapter 7, which gives details on a range of sill seals. Apart from the desirable characteristics discussed earlier, care should be taken to ensure that any selected seal is an appropriate size for the gap between the door and the sill. In the case of threshold seals, contractors should also be certain that the selected seal has good resistance to the damaging effects of steady pedestrian traffic.

FIGURE 13.8


A
INSIDE
OUTSIDE
DOOR
SWEEP SEAL
PILE
SILL
C
INSIDE
OUTSIDE
DOOR
BUBBLE MOULDING THRESHOLD SEAL
SILL
B
INSIDE
OUTSIDE
DOOR
SWEEP SEAL
SILL
D
INSIDE
OUTSIDE
DOOR
THRESHOLD SEAL RUBBER
ALUMINUM
SILL

Procedure 2

GENERAL TECHNIQUES ASSOCIATED WITH DOOR WEATHERSTRIPPING

TOOLS

(Surface preparation only)

- Hammer
- Screwdriver
- Plane
- Scraper
- Putty knife
- Sandpaper

MATERIALS

(Surface preparation only)

- Mineral spirits
- Clean white rags
- Latex wood filler
- Primer, if required

(Additional tools and materials will be required for weatherstrip installation and may be required for minor door repairs, if any).

This Procedure gives details on how to prepare door and frame surfaces for the installation of weatherstripping, and touches on application measures. Full application procedures should generally be available from the manufacturer of the chosen weatherstripping.

PREPARATION

1. Inspect the fit of the door. If it is poorly fitted, one or more the following adjustments might be beneficial:

- Remove the door from the frame and plane the edges to improve the fit around the door perimeter

- Install shims (spacer plates or gaskets) behind the existing door hinges to increase the gap at the hinge jamb and reduce the gap at the strike jamb

- If the door stops are nailed to the jamb, even out any variations in the gap around the door by removing the stops and relocating them to give a better fit, using sealant to make an airtight joint.

(In conjunction with this work, the sealing of air leakage points through the door can be carried out. See the introduction to this Worksheet for details).

2. Clean the door frame and door edges (anywhere where seals are to be applied) of loose paint, dirt, and oil. Remove existing weatherstripping. Use a plane and scraper to prepare smooth wood surfaces, if necessary. Fill indentations with latex wood filler and sand flush.

3. If the door has been removed from the hinges, re-install and adjust to give a smooth closing action.

4. Wipe all surfaces to be weatherstripped with mineral spirits and a clean white rag.

5. If sealant is to be used in the weatherstrip application, determine whether a primer is required at any point. If so, prime as necessary.

APPLICATION

1. The weatherstripping should be applied to the prepared surfaces in accordance with the manufacturer's instructions.

2. When installed, some seals may not fit tightly to the jamb, leaving small gaps through which air will continue to leak (see Figure 13.9). Where this is likely to be a problem, a fine bead of sealant should be applied to the jamb. The weatherstripping should then be installed over the bead, as shown in Figure 13.10.

3. It is difficult, when installing seals, to get a good airtight joint where the seals meet at the corner of the door frame. Contractors should make a reasonable attempt to get a good seal joint at corners, but should not go to extreme lengths to achieve a perfectly airtight seal. (Note that a few seals can be obtained with special components for providing good seals at corners.)

FIGURE 13.9

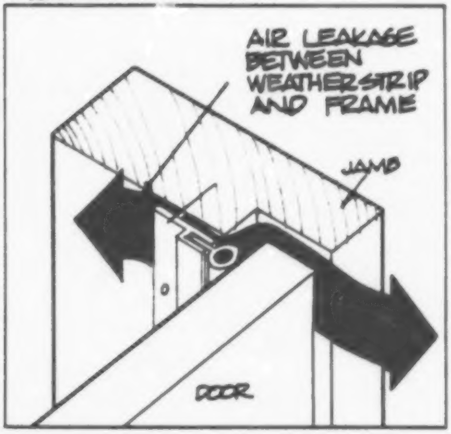
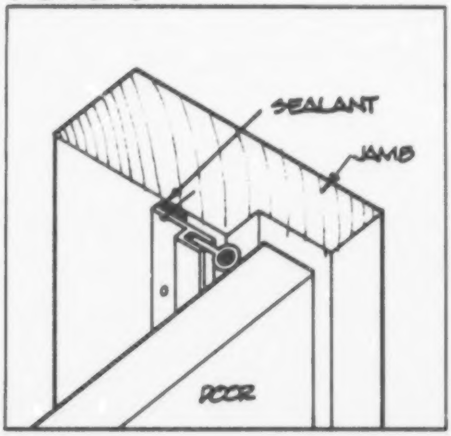


FIGURE 13.10



Worksheet 3:
Additional procedures for sliding doors

INTRODUCTION:

In addition to the types of air leakage dealt with by Doors: Worksheet 1, in sliding doors the problem of air leakage between the sliding or fixed door units and the door frame must be dealt with.

In most cases, sealing can be accomplished using the techniques outlined for sliding windows with sash (see Windows: Worksheet 4). Accordingly, no separate procedure is presented here.

Note: In the case of some types of sliding doors, special seals and installation tools may be required. In such cases, it may be advisable to have the work done by specialists who are familiar with the particular door type.

Worksheet 4:

Additional procedures for storm doors

INTRODUCTION:

In addition to the types of air leakage dealt with in Doors: Worksheets 1-3, it might seem worthwhile to seal any air leakage paths between the storm door and the door frame. However, **in this Manual it is recommended that all the sealing work be concentrated on the main doors, leaving the storm doors as unsealed units.** It is inadvisable to seal both the main and storm doors, since this creates an air lock that makes it harder to close the main door.

Leaving the storm doors relatively unsealed has a low heat loss penalty. The principal functions of a storm door are to protect the main door from weather effects in winter and to serve as a ventilation opening in summer. The storm door should not be regarded as an important part of the seal of the house envelope (though it may play a minor role if the main door is very leaky).

Glossary and Appendices

DRAFT GLOSSARY

APPENDIX 1. DATA SHEETS ON SEALANTS PAGE A1-1

APPENDIX 2. DATA SHEETS ON WEATHERSTRIPPING MATERIALS PAGE A2-1

APPENDIX 3. FEEDBACK FORM PAGE A3-1

Glossary

INTRODUCTION

This draft glossary defines specialized terminology that appears in the various chapters of this Manual. For ease of reference, the words are organized subject-by-subject, in groups that correspond to the individual chapters.

ACTIVATOR	A material which, when added to the base compound or the curing agent, as in the case of a two-part system, will speed up or initiate the curing mechanism.
ADHESION	That property of a coating or sealant which measures its ability to stick or bond to the surface to which it is applied.
ADHESION FAILURE	Failure of a compound by pulling away from the surface with which it is in contact.
BACK-UP	A material placed into a joint, primarily to control the depth of the sealant.
BEAD	A sealant or compound after application in a joint irrespective of the method of application, such as sealant bead, glazing bead, etc.
BLEEDING	The absorption of oil or other substance from a compound into an adjacent porous surface. Different from migration, which is the spreading or creeping of oil or other substance from a sealant compound out onto an adjacent non-porous surface.
BOND BREAKER	A release material to prevent adhesion of sealant to the back of a joint.
COHESIVE FAILURE	Failure of a sealant resulting from over extension of the compound caused by excessive movement in which the sealant splits and opens.
COMPATIBLE	The capability of materials to be in contact indefinitely without any adverse effects to either. Compatibility does not imply adhesion.
COMPOUND	A formation of ingredients, usually grouped as vehicle or polymer pigment and fillers to produce caulking compounds, elastomeric sealants etc.
COMPRESSION	Pressure exerted on a compound in a joint which tends to squeeze the compound, as in bedding or placing a stop in position against a bead of sealant.

CONCAVE BEAD	A bead of compound hollowed or rounded inward on the exposed surface.
CONSISTENCY	Degree of softness or firmness of a compound as supplied in the container, and varying according to the method of application, such as gun, knife, power tool, etc.
CONVEX BEAD	Bead of compound curved or rounded outward on the exposed surface.
CURE	The change of a sealant from a fluid to an elastoplastic or elastic state by a chemical reaction.
ELASTOMERIC MATERIAL	An elastic, rubber-like substance capable of stretching easily and having the ability to recover its original configuration.
GUN CONSISTENCY	A compound formulated in a degree of softness suitable for application through the nozzle of a caulking gun.
HYPALON	A one-component synthetic rubber base material.
MASTIC	Descriptive of heavy consistency compounds that remain adhesive and pliable with age.
MIGRATION	Spreading or creeping of oil or other substance from a compound out onto adjacent non-porous surfaces.
NON-DRYING	Descriptive of a compound that does not set up hard.
NON-SKINNING	Descriptive of product that does not form a surface skin after application. Usually remains tacky or sticky.
POLYBUTENE	A light coloured liquid, hydrocarbon polymer. Non-drying and widely used as a major component in caulking and sealant compounds.
POLYETHYLENE	A lightweight plastic that is resistant to chemicals and moisture. Widely used as a vapour retarder.

PRIMER	. A coating applied to improve the adhesion of sealants.
PRIMING	. Sealing of porous surface so that the sealant compound will not stain, lose elasticity, shrink excessively, etc., because of loss of oil or other substance into the surrounding materials. A sealant primer or surface conditioner may be used to promote adhesion of a curing type sealant to certain surfaces.
SAGGING	. Caused by a compound not capable of supporting its own weight in a joint or by application in joints larger than the compound is designed for, or by improper application.
SEALANT	. A compound used to fill and seal a joint or opening, as contrasted to a sealer which is a liquid used to seal a porous surface.
SHELF LIFE	. Maximum time a material can be stored before use.
SHRINKAGE	. The decrease in volume of a material which occurs when the material loses part or all of its volatile consituents.
SLUMP	. Failure of a mastic or sealant in a joint to support its own weight.
STAINING	. Discoloration of porous substrate caused by absorption of oil, solvents etc., from a sealant material in contact with the substrate.
SUBSTRATE	. The surface to which a primer, sealer, mastic or sealant is applied.
TOOLING	. The operation of pressing a material into a joint in order to press the compound against the sides of a joint to ensure good adhesion and to remove air bubbles. Also the finishing off of the surface of a sealant compound etc., in a joint so that it is flush with the surface. A narrow, blunt bladed tool is used for this purpose.

TWO-PART COMPOUND	. A product which is necessarily packaged in two separate containers. It is comprised of a base and the curing agent. The two components are uniformly mixed just prior to its use since, when mixed, it cures and its useful life is quite limited from the standpoint of application characteristics.
VOLATILE	. The property of liquids to change into a gas and pass away by evaporation, under normal atmospheric conditions.

TERMINOLOGY RELATED TO FOUNDATIONS

BACK FILL	The material used to re-fill an excavation around the outside of a foundation wall.
BASE COURSE	In masonry, the first or bottom course of brick, stone or concrete blocks.
BEAM	A principal structural member usually of wood, steel or concrete used between posts, columns or walls to support vertical loads.
BEAM POCKET	A notch formed at the top of a foundation wall to receive and support the end of a beam.
BEARING	The part of a joist, rafter, truss or beam which actually rests on its support and the area of the support on which it rests.
BED	In masonry, the horizontal layer of mortar on which each course of masonry is laid.
BOND	In masonry, the pattern in which bricks or blocks are laid to tie the individual units together so that the entire wall they comprise will tend to act as a complete unit.
CONDUIT, ELECTRICAL	A pipe or tube, usually metal, in which wiring is installed.
CRAWL SPACE	A shallow space between the lowest floor of a house and the ground beneath.
DAMPPROOFING	The process of coating the interior or exterior of a foundation wall, floor etc., with bituminous emulsions and plastic cements. To prevent or interrupt the capillary draw of moisture into the wall or floor system to the interior of the foundation.
DECAY	The disintegration of wood materials due to action of wood destroying fungi.
DRY ROT	A term loosely applied to many types of decay but especially to that which, when in an advanced stage, permits the wood to be easily crushed to a dry powder.
EXPANSION JOINT	A joint in a concrete or masonry structure designed to permit expansion without damage to the structure.

FIRE STOP	A block or stop used between studs in a wall of a building to prevent the spread of fire and smoke through the air space within the wall.
FOOTING	The widened section, usually concrete, at the base or bottom of a foundation wall, pier, or column.
FOUNDATION	The lower portion, usually concrete or masonry and including the footings, which transfers the weight of, and loads on, a building to the ground.
GRADE LINE	A pre-determined line indicating the proposed elevation of the ground surface around the building.
GROUT	A thin mixture of cement mortar and additional water.
HEADER	A wood member at right angles to a series of floor joists at which the floor joists terminate. When used at openings in the floor the header supports the floor joists and acts as a beam.
HEADER JOISTS	A wood member broadly comparable to a header, but parallel to a series of joists.
JOIST	One of a series of horizontal wood members, usually of 38mm thickness, used to support a floor, ceiling, or roof.
MASONRY	Stone, brick, hollow tile, concrete block, or tile, and sometimes poured concrete and gypsum block, or other similar materials, or a combination of same, bonded together with mortar to form a wall, pier, buttress etc.
MONOLITHIC	A term used for concrete construction poured or cast in one unit without joints.
PARGING	A coat of plaster or cement mortar applied to masonry or concrete walls.
PILE	A heavy timber, or pillar of metal, wood or concrete, forced into the earth or cast in place to form a foundation member.

DRAFT
GLOSSARY
Continued

PRESSURE TREATED	The impregnation of wood or plywood with chemicals under pressure to prevent decay and insect (termite) attack.
SILL PLATE	A structural member anchored to the top of a foundation wall, upon which the floor joists rest.
SOIL STACK	A general term for the vertical main of a system of soil, waste, or vent piping.
SUBFLOOR	Boards or sheet material laid on joists under a finish floor or underlay material.
WATER-PROOFING	A process of coating the exterior of a foundation with bituminous, felt, cementitious coatings etc. to prevent water penetration into or through a wall system under continuous hydrostatic pressure.
WATER TABLE	The level below which the ground is saturated with water.
WYTHE	A continous vertical section of a masonry wall having a thickness of one masonry unit.

TERMINOLOGY RELATED TO FLOORS

FINISH FLOOR	. The top finished surface of a floor, which may consist of wood, asphalt, cork, linoleum, tile, carpet. etc.
FLOOR	. The continous supporting surface extending horizontally throughout a building, constituting one level or stage in the structure.
FLOORING	. The general name given to all materials used to cover a floor.
HARDWOOD STRIP FLOORING	. Machined strips of wood having a tongue-and-groove jointing system along the full length, as well as on each end.
PARQUET FLOORING	. A pre-assembled patterned square or rectangular hardwood flooring tile with square or tongue-and-groove edges.
PLANK FLOORING	. A strip flooring having a tongue-and-groove jointing system machined along both edges and both ends.
PLUMBING STACK	. A general term for the vertical main of a system of soil, waste or vent piping.
SLEEPER FLOOR	. A wood floor laid over an existing concrete floor and supported on the concrete floor.
SUBFLOOR	. Boards or sheet material laid on joists under a finish floor or underlay material.
SUSPENDED FLOOR	. A floor supported by the outside walls - generally found above earth or unfinished crawlspaces in wood foundations.
TONGUE-AND-GROOVE	. Any lumber, such as board, plank or sheet materials used for floors, that is machined with a groove on one edge and a matching tongue on the opposite edge.
QUARTER ROUND	. Small moulding with a cross section of a quarter of a circle.
UNDERLAY	. Any lumber, plank, or sheet materials placed between subfloor and finish floor, to provide support or a smooth surface for finish floor materials.

TERMINOLOGY RELATED TO WALLS

BALLOON FRAMING	. A method of wood-frame construction in which the studs extend in one piece from the foundation sill plate to the top plates supporting the roof.
BASEBOARD	. A moulded board fitted to the bottom section of a wall to conceal the joint between the floor and wall finish.
BASE COURSE	. In masonry, the first course or bottom course of brick or masonry blocks.
BATTEN	. A narrow strip of wood used to cover joints between boards or panels.
BOTTOM PLATE	. The lower horizontal member of a wood-framed wall, nailed to the wall studs and to the floor framing members.
CORNER BEAD	. In plastering, a metal strip placed on external corners before plastering, to protect, align and reinforce them. In gypsum board finish, a strip of metal or wood fixed to external corners to protect them from damage.
CASED OPENING	. An interior opening without a door; finished with jamb and casing (trim).
CORNERITE	. Metal lath cut in strips and formed into a right-angled channel. Used in internal angles of plastered walls and ceilings to reinforce them.
FURRING	. Strips of wood applied to a wall or other surface as a nailing support for finish material, or to give the wall an appearance of greater thickness.
INTERIOR FINISH	. The covering used on interior walls and ceilings.
JOINT CEMENT	. A powder which is mixed with water and applied to the joints between sheets of gypsum board.
LATH	. A building element of wood, metal, gypsum or fibreboard fastened to the frame of a building to serve as a base for plastering.

MITRE JOINT	A joint formed by cutting two boards at 45 degrees and butting them together to make a right angle.
NON-BEARING PARTITION	A wall which separates space into rooms, but supports no vertical load except its own weight.
RECEPTACLE	A wall-mounted electrical outlet.
STUD	One of a series of vertical wood-frame members (usually 38mm thick) used in the construction of wall frames.
TAPING	In drywall construction, the masking of joints between sheets by means of paper tape (or other types of tape) which is smoothed over with joint cement.
TOP PLATE	The horizontal member nailed to the top of wall studs to form the top of a wall frame. Sometimes installed as a double top plate.

TERMINOLOGY RELATED TO ATTICS AND ROOF SPACES

AIR SPACE	A cavity or unfilled space between two constituent parts in a roof system or other enclosure element of a building.
ATTIC	A roof space between the top floor ceiling and the roof of a building.
CHIMNEY, FACTORY-BUILT	A chimney consisting entirely of factory made parts, each designed to be assembled with the other without requiring field fabrication.
CHIMNEY, MASONRY	A field constructed chimney of brick, stone, concrete, or masonry units.
COLLAR	A metal cap flashing around a vent pipe projecting above a roof deck.
CONDENSATION	The change from water vapour to liquid water, resulting from a drop in temperature of an air vapour mixture.
CONDENSATION, CONCEALED	Water vapour that changes to liquid water within the roofing system and is not seen.
CONDENSATION, SURFACE	Water vapour that changes to liquid water and appears on the colder exposed surfaces of a roofing system.
DEW POINT	The temperature at which a sample of humid air, cooled from some temperature, becomes saturated and at which water vapour begins to condense.
FIRE STOP	A wood or metal stop used in walls or around a masonry or metal chimney to prevent the spread of fire and smoke through an air space.
GABLE	The triangular end of an exterior wall from the level of the eaves to the ridge of a double-sloped roof. A gable roof is a ridged or double-sloped roof which terminates at one or both ends in a gable. A gable end is the end wall of a building with a gable formed by the roof.
GAMBREL	A type of roof which has its slope broken by an obtuse angle, so that the lower slope is steeper than the upper slope. A double-sloped roof having two inclines on each slope.

HEADER	. The beam into which the common joists are fitted when framing around a roof opening. The headers are placed so as to fit between two long beams or trimmers to support the joist ends.
HIP	. The sloping line formed by the meeting of two sloping sides of a roof whose eaves meet at a right-angle. A hip roof is one that rises by inclined planes from all four sides of a building to form hips at the intersection of adjacent roof slopes.
ICE DAM	. Ice formation at the eaves of snow-covered sloping roofs that forms an obstruction to the drainage of snow-melt water.
INSULATION	. A material used as a part of a building enclosure to retard the flow of heat through the enclosure.
JOIST	. One of a series of horizontal wood members, usually of 38mm thickness, used to support a floor, ceiling, or roof.
MANSARD	. A roof which rises by inclined planes from all four sides of a rectangular building. Each sloping roof has two inclines, the lower one usually very steep and the upper one almost flat.
OVERHANG	. The part of a roof structure that extends beyond the exterior walls of a building.
PARAPET	. A low wall along the edge of, and surrounding, a roof deck. It is generally an extension of exterior building walls or party and fire walls, usually extending about a metre or less above a roof.
PLANK DECK	. Wood deck of planks usually 40mm to 90mm thick and 150mm to 200mm wide laid on the flat with tongued-and-grooved or splined edges, and spiked together.

DRAFT
GLOSSARY

Continued

PURLINS	Horizontal roof members used to support rafters between the plate and ridge board.
RAFTER	One of a series of structural members of a roof designed to support roof loads. The rafters of a flat roof are sometimes called roof joists.
ROOFING	The materials applied to the structural parts of a roof to make it waterproof.
SOIL STACK	A general term for the vertical main of a system of soil, waste, or vent piping.
SOFFIT	The underside of any subordinate member of a building. For roofs the underside of a roof overhang.
STACK EFFECT	Air flow into a building at the lower levels and out at the higher levels caused by the pressure difference that exists because of the temperature differences of the air masses inside and outside of a building. This is similar to the phenomenon that produces draft in a chimney.
TRUSS	A structural unit consisting of such members as beams, bars, and ties, usually arranged to form triangles. Provides rigid support over wide spans with a minimum amount of material.
VAPOUR BARRIER	A watertight material used to prevent the passage of mositure or water vapour into or through structural elements (floors, walls, ceilings).

BAR	Either vertical or horizontal member that extends the full height or width of the glass opening.
BEAD	A sealant or compound applied in a joint irrespective of the method of application, such as sealant bead, glazing bead etc. Also a molding or stop used to hold glass in position.
BED OR BEDDING	The bead of sealing compound applied between the glass and the stationary stop or sill of the sash or frame, and usually the first bead of sealing compound to be applied when setting glass or panels.
BEVEL OF BEAD	Bead of sealing compound applied so as to have a slanted top surface so that water will drain away from the glass.
BLIND STOP	A thin strip of wood machined so as to fit the exterior vertical edge of the pulley stile or jamb and keep the sash in place.
CASING	Molding of various widths and thicknesses used to trim window openings.
CHANNEL	A three-sized, U-shaped opening in sash or frame to receive glass or panel, with or without removable stop or stops. Contrasted to a rabbet which is a two-sided, L-shaped section, as with face glazed window sash.
CHANNEL GLAZING	The sealing of the joints around glass set in a U-shaped channel employing removable stops.
CHECK RAILS	Meeting rails sufficiently thicker than the window to fill the opening between the top and bottom sash made by the check stop or parting stop in the frame. They are usually bevelled and rabbeted.
EXTERIOR GLAZED	Glass set from the exterior of the building.
EXTERIOR STOP	The removable molding or bead that holds the glass or sash in place when it is on the exterior side of the glass or sash, as contrasted to an interior stop located on the interior side.

FACE GLAZING	On rabbeted sash without stops, the triangular bead of sealing compound applied with a glazing knife after bedding, setting and clipping the glass in place.
FRAME	A group of wood parts machined and assembled to form an enclosure and support for a window or sash.
GLAZING	The securing of glass in prepared openings in windows, door panels, partitions, etc.
HEAD JAMB	The horizontal member forming the top of the frame.
HEEL BEAD	Sealant applied at the base of channel, after setting glass and before the removable stop is installed. One of its purposes is to prevent leakage past the stop. Sealant must bridge the gap between the glass and frame.
INTERIOR GLAZED	Glass set from the interior of the building.
INTERIOR STOP	The removable molding or bead that holds the glass or sash in place, when it is on the interior side of the glass, as contrasted to an exterior stop which is located on the exterior side of the glass or sash.
JAMB	Part of frame that surrounds and contacts the window or sash.
JAMB LINER	A small strip of wood which, when applied to the inside edge of a jamb, increases its width for use in thicker walls.
MULLION	A horizontal or vertical member that holds together two adjacent panes of glass or units of sash or sections of curtainwall.
MUNTIN	In a sash having horizontal and vertical bars that divide the window into smaller panes of glass, the bars are termed muntin bars. Similar to mullion but lighter weight.

NEEDLE GLAZING OR BEAD	Application of a small bead of sealing compound at the sight-line by means of a gun nozzle about 3mm in opening size.
PARTING STOP	A thin strip of wood let into the jamb of a window frame to separate the sashes.
PULLEY STILE	A side jamb into which a pulley is fixed and along which the sash slides.
PRIMING	Sealing of a porous surface so that the sealing compound will not stain, lose elasticity, shrink excessively, etc., because of loss of oil or other substance into surrounding materials. A sealant primer or surface conditioner may be used to promote adhesion of a curing type sealant to certain surfaces.
RABBET	A two-sided L-shaped recess in sash or frame to receive glass or panels. When no stop or molding is added, such rabbets are face glazed. Addition of a removable stop produces a three-sided U-shaped channel.
RABBETED JAMB	A jamb with a rectangular groove along one or both edges to receive a window or sash.
RACKING	Movement and distortion of sash or frames because of lack of rigidity, or caused by adjustment of ventilator sections. Puts excessive strain on the window and may result in joint failure.
RAILS	Cross, or horizontal, pieces of the framework of a sash or screen.
SASH	A single assembly of stiles and rails made into a frame for holding glass, with or without dividing bars.
SIDE JAMB	The upright member forming the vertical side of the frame.
SILL	The horizontal member forming the bottom of the frame.
STILES	Upright, or vertical, outside pieces of a sash or screen.

TERMINOLOGY RELATED TO DOORS

CASING	Molding of various widths and thicknesses used to trim door openings.
DOOR FRAME	The part of a doorway to which a door is hinged and against which it closes.
HEAD JAMB	The horizontal member forming the top of the frame.
HINGE JAMB	The upright member forming the vertical side of the frame on which the hinges or butts are attached.
INNER FACE	The door surface which faces the interior or warm side of the liveable area.
JAMB	Part of the frame that surrounds and contacts the door.
MEETING RAILS	The vertical members between the horizontal sliding section and fixed section of a patio door or between a double opening metal or wood door unit.
OUTER FACE	The door surface which faces the exterior or cold side of the liveable area.
SILL	The horizontal member forming the bottom of the door frame which serves as a step preventing rain entry, and forms a division between the interior finish floor and the outside construction.
STOP	A trim strip of wood which may be an integral part of the door frame, or attached to the surface of the jambs to keep the door in place, stop drafts, and stop the passage of light.
STRIKE JAMB	The upright member forming the vertical side of the frame on which the striker plate is attached.
THRESHOLD	A wood member, bevelled or tapered on each side, used to close the space between the bottom of a door and the sill or floor underneath.
WARPAGE	The twisting, bending or distortion of the door, frames or structural components.

Appendix 1. Data Sheets on Sealants

INTRODUCTION

This Appendix contains 13 data sheets. Each of these outlines the characteristics, advantages, limitations, and uses of a particular type of sealant. Together, the thirteen data sheets cover the most common sealant types and a number of specialized types. Note that the information supplied refers to normal, proper usage. Characteristics such as toxicity, typical service life, acceptable joint movement, etc. will vary if the sealant is not used as directed or intended.

It must be emphasized that the data sheets are a highly simplified summary, prepared for the convenience of contractors using this manual. Many sealant types, as was mentioned in Chapter 7, have a range of formulations that vary from manufacturer to manufacturer. Thus, the data sheets give only general details of the range of properties that will be encountered with each type. For more specific details, the contractor is advised to consult the specifications for individual products.

The data sheets cover the following sealants:

Data Sheet 1:	Oil and resin base caulking compounds
Data Sheet 2:	Butyl rubber sealant
Data Sheet 3:	Water-based vinyl-acetate caulk
Data Sheet 4:	Water-based vinyl-acrylic sealant
Data Sheet 5:	Water-based acrylic sealant
Data Sheet 6:	Solvent-based acrylic sealant
Data Sheet 7:	Chlorosulfonated polyethylene (hypalons) sealant
Data Sheet 8:	Silicone sealant (one part)
Data Sheet 9:	Polysulfide sealant (one part)
Data Sheet 10:	Polyurethane sealant (one part)

Data Sheet 11: Urethane foam sealant (one or two part)

Data Sheet 12: Acoustical sealant

Data Sheet 13: Silicone RTV foam sealant

For an overview discussion of sealant selection factors, refer to Chapter 7.

DATA SHEET 1

OIL AND RESIN BASE CAULKING COMPOUNDS

GENERAL

Technical description: Oil-based mastic or putty-type sealant

Types available: Gun grade and knife grade

Typical colours: Gun grade available in a wide range of colours; knife grade in white, gray, tan

Typical price: Low cost

Odour while curing: Oil or solvent odour

Toxicity:

SERVICE CHARACTERISTICS

Typical service life (exterior use): 3-5 years

In service temperature range: -28°C to 82°C

Resistance to water immersion: Poor to fair
to abrasion: Poor
to fire: Poor

Adhesion to dry surfaces: Fair to good
to wet surfaces: Poor

Maximum joint size: The general rules concerning the width-to-depth ratio of sealants in active joints are not applicable to oil-base caulking compounds when employed in joints with minimal activity. Life expectancy of the oil-based caulk is increased proportionately as the volume in the joint is increased. Shallow joints should be avoided.

Maximum joint movement: ± 1%

DATA SHEET 1 (continued)

OIL AND RESIN BASE CAULKING COMPOUNDS

APPLICATION CHARACTERISTICS

Ease of application: Very easy to easy

Primer requirements: Priming of porous surfaces required

Temperature requirements: Above 4.4°C

Approximate drying time to touch: 1-2 days
to cure: Up to 1 year

Shrinkage: 5% to 10%

Handling precautions: Ventilation during curing to remove flammable or irritating vapours

ADVANTAGES

- Lowest cost among sealants
- Suitable for non-moving indoor or outdoor joints where little or no expansion or contraction of the materials to be sealed is likely to occur

LIMITATIONS

- Lowest performance of sealant types
- Dries hard and can deform permanently
- Porous surfaces, such as wood and concrete, require priming
- May bleed or allow migration of oils to adjacent surfaces

DATA SHEET 1 (continued)

OIL AND RESIN BASE CAULKING COMPOUNDS

USES

Oil-based caulking compounds are widely used and successfully employed in areas where the demands placed on sealants are not great. Linseed oil putties are extensively used for glazing window sashes. Their useful life can be extended considerably by priming the wood sash prior to application and by following a good paint maintenance schedule. Oil-based caulks must be used with materials having low thermal coefficients of expansion and contraction and are therefore only used as general sealants in weatherproofing around windows and doors and for sealing joints in wood and masonry.

SEALANT
MATERIALS
(continued)

DATA SHEET 2

BUTYL RUBBER SEALANT

GENERAL

Technical description: Synthetic rubber sealant formed by the co-polymerization of isobutylene with isoprene

Types available: Gun grade

Typical colours: White, black, aluminum, grey, bronze, brown, redwood, ivory

Typical price: Low to moderate cost

Odour while curing: Aromatic

Toxicity:

SERVICE CHARACTERISTICS

Typical service life (exterior use): 4-10 years

In service temperature range: -28°C to 93°C

Resistance to water immersion: Fair to good
to abrasion: Fair
to fire: Fair

Adhesion to dry surfaces: Fair to good
to wet surfaces: Poor

Maximum joint size: 12 mm width

Maximum joint movement: ± 5% to ± 10%

DATA SHEET 2 (continued)

BUTYL RUBBER SEALANT

APPLICATION CHARACTERISTICS

Ease of application: Easy

Primer requirements: Generally no primer required

Temperature requirements: 4.4°C to 50°C

Approximate drying time to touch: 2-72 hours
to cure: 120 days

Shrinkage: 10% - 35%

Handling precautions: Precautions may be necessary. For instance, ventilate during curing to remove flammable vapours or irritating vapours. Avoid repeated or prolonged skin contact.

ADVANTAGES

- Adhesion good to metal and masonry
- Good water resistance
- Works well when both sides of a joint or seam are the same material

LIMITATIONS

- Can only be applied above 4.4°C
- Wide variation in cure time and adhesion due to variations in formulation
- High shrinkage
- May be sticky or stringy during application
- Must be allowed to cure for minimum of one week before painting

USES

Butyl Rubber sealants are often recommended for glazing in wood sashes and for sealing around interior doors, windows, and interior masonry joints not subject to movement. This type of sealant is not recommended for areas subject to high moisture conditions. Butyl sealants vary considerably in formulation and therefore should be selected on the basis of a high solids content (which maximizes adhesion characteristics). Butyl sealants are solvent curing and therefore ventilation will be required for up to 3 days.

DATA SHEET 3

WATER-BASED VINYL-ACETATE CAULK
(Also Referred To As Vinyl-Acetate Latex Caulk)

GENERAL

Technical description: Water-based emulsion sealant formulated from acrylic polymers

Types available: Gun grade

Typical colours: White

Typical price: Low cost

Odour while curing: Latex paint odour

Toxicity: Non-toxic

SERVICE CHARACTERISTICS

Typical service life (exterior use): Less than ten years

In service temperature range: -28°C to 65°C

Resistance to water immersion: Poor
to abrasion: Poor
to fire: Fair

Adhesion to dry surfaces: Good to fair
to wet surfaces: Good to fair

Maximum joint size: 9 mm width

Maximum joint movement: ± 2%

DATA SHEET 3 (continued)

WATER-BASED VINYL-ACETATE CAULK

APPLICATION CHARACTERISTICS

Ease of application: Very easy to use

Primer requirements: No primer required

Temperature requirements: Above 4.4°C

Approximate drying time to touch: 1/2-1 hour
to cure: 14-30 days

Shrinkage: 5% to 10%

Handling precautions: No special precautions

ADVANTAGES

- Lowest cost among latex sealants
- Can be applied to damp surfaces
- Paintable soon after application
- Cleans up with water
- Works well on small joints and non-moving joints
- No solvent release
- Easy to use and safe for indoor use.

LIMITATIONS

- Lowest performance among latex sealants
- Poor outdoor exposure resistance
- Dries fairly hard; not as flexible as vinyl acrylic or all-acrylic latex sealants
- Cannot be stored below 5°C
- Can only be applied above 4.4°C
- Not good in permanently damp environments or continous water immersion

DATA SHEET 3 (continued)

WATER-BASED VINYL-ACETATE CAULK

USES

Vinyl acetate sealants may be considered to be typical "tub and tile" caulks. They have the lowest performance of all the acrylic emulsion sealants. This sealant has limited resistance to ultraviolet light exposure and weathering, and therefore is not recommended for outdoor use (such as glazing windows). The sealant is satisfactory for sheltered indoor applications in joints which experience little movement. Vinyl acetate sealants are not recommended for application where the sealant will be exposed to continuous water immersion. Provides good performance for use on wood, glass and metal surfaces.

DATA SHEET 4

WATER-BASED VINYL-ACRYLIC SEALANT
(Also Referred To As Vinyl Acrylic Latex Sealant)

GENERAL

Technical description: Water-based emulsion sealant formulated from acrylic polymers.

Types available: Gun grade

Typical colours: White, ivory, aluminum grey grey, brown, bronze

Typical price: Low cost

Odour while curing: Latex paint odour

Toxicity: Non toxic

SERVICE CHARACTERISTICS

Typical service life (exterior use): Up to 10 years

In service temperature range: -28°C to 65°C

Resistance **to water immersion:** Poor
to abrasion: Poor
to fire: Fair

Adhesion to dry surfaces: Good to fair
to wet surfaces: Good to fair

Maximum joint size: 9 mm width

Maximum joint movement: ± 2%

DATA SHEET 4 (continued)

WATER-BASED VINYL-ACRYLIC SEALANT

APPLICATION CHARACTERISTICS

Ease of application: Very easy to use

Primer requirements: No primer required

Temperature requirements: Above 4.4°C

Approximate drying time to touch: 1/2-1 hour
to cure: 14-30 days

Shrinkage: 5 to 10%

Handling precautions: No special precautions

ADVANTAGES

- Intermediate cost among latex sealants
- Can be applied to damp surfaces
- Paintable soon after application
- Cleans up with water
- Works well on small joints or joints that have minor movement
- No solvent release
- Easy to use and safe for indoor use

LIMITATIONS

- Intermediate performance among latex sealants
- Poor to fair outdoor exposure resistance
- Dries fairly hard, but more flexible than vinyl acetate caulk, not as flexible as an all-acrylic latex sealant
- Cannot be stored below 5°C
- Can only be applied above 4.4°C
- Not good in permanently damp environments or for continuous water immersion

USES

Vinyl acrylic sealants may be considered to be general purpose emulsion sealants having more resistance to ultraviolet light exposure and weathering than vinyl acetate sealants. The vinyl acrylic does not retain flexibility on ageing and exposure as well as an all-acrylic sealant. However, it may be considered for both indoor and outdoor use in general applications on wood, glass, and metal surfaces.

DATA SHEET 5

WATER-BASED ACRYLIC SEALANT
(Also Referred To As Acrylic Latex Sealant)

GENERAL

Technical description: Water-based emulsion sealant formulated from acrylic polymers

Types available: Gun grade

Typical colours: Available in a wide range of colours, including white

Typical price: Moderate cost

Odour while curing: Latex paint odour

Toxicity: Non-toxic

SERVICE CHARACTERISTICS

Typical service life (exterior use): Over 10 years

In service temperature range: -28°C to 65°C

Resistance **to water immersion:** Poor
to abrasion: Poor
to fire: Fair

Adhesion to dry surfaces: Good to fair
to wet surfaces: Good to fair

Maximum joint size: 9 mm width

Maximum joint movement: ± 2%

DATA SHEET 5 (continued)

WATER-BASED ACRYLIC SEALANT

APPLICATION CHARACTERISTICS

Ease of application: Very easy to use

Primer requirements: No primer required, except for metal in special cases

Temperature requirements: Above 4.4°C

Approximate drying time to touch: 1/2-1 hour
to cure: 14-30 days

Shrinkage: 5 to 10%

Handling precautions: No special precautions

ADVANTAGES

- No solvent release
- Cleans up with water
- Can be applied to damp surfaces
- Wide selection of colours
- More flexible than vinyl-acrylic or vinyl acetate latex sealants
- Has excellent weathering resistance
- Safe for indoor use
- Paintable soon after application

LIMITATIONS

- Highest cost among latex emulsion sealants
- Cannot be stored below 5°C
- Can only be applied above 4.4°C
- Not good in permanently damp environments or for continuous water immersion
- May be susceptible to mildew
- Metal surfaces often require painting or priming if oxidized

DATA SHEET 5 (continued)

WATER-BASED ACRYLIC SEALANT

USES

Acrylic latex sealants may be considered to be a high performance emulsion sealant which provides good flexibility and weathering characteristics and has excellent peel strength on non-porous surfaces such as aluminum, glass, and ceramic tile. The sealant may be used to seal joints in wood surfaces; however the peel strength is somewhat reduced if water and plasticizer in the sealant is absorbed into the wood. May be considered a high performance sealant for indoor or outdoor use in joints having little or no movement.

DATA SHEET 6

SOLVENT-BASED ACRYLIC SEALANT (NOT RECOMMENDED FOR INDOOR USE)

GENERAL

Technical description: Solvent-based acrylic sealant formulated from unmodified acrylic polymer

Types available: Gun grade

Typical colours: White, black, grey, plus five colours

Typical price: Moderate to high cost

Odour while curing: Strong odour

Toxicity: Potentially toxic

SERVICE CHARACTERISTICS

Typical service life (exterior use): 20 years

In service temperature range: -40°C to 150°C

Resistance to water immersion: Poor
to abrasion: Fair
to fire: Poor

Adhesion to dry surfaces: Excellent
to wet surfaces:

Maximum joint size: 19 mm width

Maximum joint movement: ± 7 1/2%

DATA SHEET 6 (continued)

SOLVENT-BASED ACRYLIC SEALANT

APPLICATION CHARACTERISTICS

Ease of application: Moderate to difficult, depending upon temperature of sealant

Primer requirements: No primer required

Temperature requirements: Above 4.4°C

Approximate drying time to touch: 1-7 days
to cure: 14-21 days

Shrinkage: Up to 5%

Handling precautions: Precautions are necessary, such as ventilation to remove potentially toxic vapours and gloves to prevent skin contact.

ADVANTAGES

- Excellent adhesion
- Good colour stability
- Can be self healing if punctured or torn
- Good resistance to chemical solvents

LIMITATIONS

- Will crack paint film and cause discolouration or staining
- Ventilation needed during application and curing
- Can only be applied above 4.4°C
- Not recommended for joints that have excessive movement
- Poor flexibility at low temperatures
- Not recommended for continuous immersion in water

DATA SHEET 6 (continued)

SOLVENT-BASED ACRYLIC SEALANT

USES

Solvent-based acrylic sealants are for exterior use only. They may be used for filling all butt and miter joints, heel beads under glass, back bedding of glass or wood materials, etc. **Not recommended for indoor use.**

DATA SHEET 7

CHLOROSULFONATED POLYETHYLENE (HYPALONS) SEALANT (NOT RECOMMENDED FOR INDOOR USE)

GENERAL

Technical description: Solvent-based chemically curing elastomeric polyethylene polymer sealant

Types available: Gun grade (cartridges only recommended; not for power equipment)

Typical colours: White and aluminum grey

Typical price: Moderate to high cost

Odour while curing: Strong odour

Toxicity: Potentially toxic

SERVICE CHARACTERISTICS

Typical service life (exterior use): 10 to 20 years

In service temperature range: -40°C to 104°C

Resistance to water immersion: Good
to abrasion: Fair
to fire: Good

Adhesion to dry surfaces: Good
to wet surfaces: Poor

Maximum joint size: 15 mm width

Maximum joint movement: ± 12 1/2%

DATA SHEET 7 (continued)

CHLOROSULFONATED POLYETHYLENE (HYPALONS) SEALANT

APPLICATION CHARACTERISTICS

Ease of application: Easy

Primer requirements: Primer not usually required

Temperature requirements: Above 10°C

Approximate drying time to touch: 24-48 hours
to cure: 30-120 days

Shrinkage: 14%

Handling precautions: Precautions are necessary, such as ventilation to remove potentially toxic vapours and gloves to prevent skin contact.

ADVANTAGES

- Elastic: can flex without permanent deformation
- Excellent colour retention
- Cures to a durable rubber-like consistency

LIMITATIONS

- Recommended for exterior use only
- Slow curing
- Can only be applied above 10°C (50°F)
- Not recommended for application on surfaces where there is frost or moisture
- Cannot be stored above 28°C

DATA SHEET 7 (continued)

CHLOROSULFONATED POLYETHYLENE (HYPALONS) SEALANT

USES

Hypalons sealants are solvent-based sealants and are for exterior use only. They are generally used on and between concrete, steel, most metals, wood, glass, stone, brick etc. without priming and where no staining of surfaces can be tolerated. **Not recommended for indoor use.**

DATA SHEET 8

SILICONE SEALANT (one part)

GENERAL

Technical description: Solvent-free silicone compound moisture curing

Types available: Gun grade

Typical colours: Grey, white, black and clear

Typical price: High cost

Odour while curing: Strong odour during application

Toxicity: Non-toxic

SERVICE CHARACTERISTICS

Typical service life (exterior use): Over 20 years

In service temperature range: -54°C to 175°C

Resistance to water immersion: Poor
to abrasion: Fair
to fire: Good

Adhesion to dry surfaces: Good to excellent
to wet surfaces: Poor

Maximum joint size: 25 mm width

Maximum joint movement: ± 12% to ±50%

DATA SHEET 8 (continued)

SILICONE SEALANT (one part)

APPLICATION CHARACTERISTICS

Ease of application: Easy

Primer requirements: May require primers for wood, steel, or anodized aluminum

Temperature requirements: -29°C to 38°C

Approximate drying time to touch: 10 minutes to 1 hour
to cure: 24 hours to 14 days

Shrinkage: Nil to 3%

Handling precautions: Precautions are necessary, such as ventilation during curing to remove irritating vapours. Uncured sealant irritates eyes. Avoid repeated or prolonged skin contact.

ADVANTAGES

- Elastic; can flex without permanent deformation
- Good for large moving joints
- Can be applied at low temperatures
- Good adhesion to most materials if correct primer is used
- Good resistance to failure from temperature extremes

LIMITATIONS

- May require primers on wood, steel, or some treated aluminum surfaces
- Careful surface preparation required
- Most silicones cannot be painted unless specified as "paintable"
- Ventilation required during application and curing
- Not recommended for continuous immersion in water
- High cost

SILICONE SEALANT (one part)

USES

Solvent-free silicone sealant is a one part formulation that cures in the presence of atmospheric moisture to produce a flexible, watertight seal. The sealant can be used with most building materials in any combination: stone, masonry, concrete, ceramics, wood, steel, aluminum, and many plastics. In many cases, no primer is required; however it is recommended that, prior to use, a test bead of sealant be applied on the material to be sealed, in order to check for adhesion.

One part silicone sealants are available in a variety of types, such as those that are paintable and for exterior and interior use; or mildew and moisture resistant types for use as a bathtub caulk; or construction grade types used typically for exterior use under exposure to severe weathering conditions.

DATA SHEET 9

POLYSULFIDE SEALANT (one part)

GENERAL

Technical description: Mositure curing elastomeric polysulfide polymer

Types available: Gun grade

Typical colours: Limestone, white, black, aluminum grey, bronze, brown and grey

Typical price: Moderate to high cost

Odour while curing: Characteristic polysulfide odour

Toxicity: Potentially toxic

SERVICE CHARACTERISTICS

Typical service life (exterior use): Over 20 years

In service temperature range: -43°C to 121°C

Resistance to water immersion: Good
to abrasion: Poor
to fire: Poor

Adhesion to dry surfaces: Good
to wet surfaces: Poor

Maximum joint size: 19 mm to 25 mm width

Maximum joint movement: ± 12% to ±25%

DATA SHEET 9 (continued)

POLYSULFIDE SEALANT (one part)

APPLICATION CHARACTERISTICS

Ease of application: Difficult

Primer requirements: Primer required

Temperature requirements: Above 16°C

Approximate drying time to touch: 12-48 hours
to cure: 60 days

Shrinkage: Nil

Handling precautions: Precautions are necessary, such as ventilation to remove potentially toxic vapours and gloves to prevent skin contact

ADVANTAGES

- Elastic; can flex without permanent deformation
- Excellent durability, flexibility
- Good for large moving joints
- Good resistance to deterioration when immersed in water
- No sag or flow when applied to vertical or overhead joints

LIMITATIONS

- Primer needed to enhance adhesion to porous sufaces
- Careful surface preparation required
- Can only be applied above 16°C (60°F)
- Cannot be applied to surfaces contaminated with bituminous materials
- Ventilation needed during application and curing
- Gloves required during application

DATA SHEET 9 (continued)

POLYSULFIDE SEALANT (one part)

USES

One part polysulfide sealants have the ability to maintain integrity during movements of extension and compression. They are ideally suited for use on stone, masonry, and concrete surfaces. Application requires that the points be properly cleaned and primed. The primer serves to reinforce the surfaces and prevent possible sealant reaction with the chemical composition of the masonry, concrete etc.

DATA SHEET 10

POLYURETHANE SEALANT (one part)

GENERAL

Technical description: One part moisture curing urethane polymer

Types available: Gun grade

Typical colours: Limestone, white, black, aluminum, grey, bronze, red, green, and tan

Typical price: High cost

Odour while curing:

Toxicity: Potentially toxic

SERVICE CHARACTERISTICS

Typical service life (exterior use): 20-30 years

In service temperature range: -40°C to 121°C

Resistance to water immersion: Good to excellent
to abrasion: Good
to fire: Poor

Adhesion to dry surfaces: Good to excellent
to wet surfaces: Poor

Maximum joint size: 19 mm width

Maximum joint movement: ±25%

DATA SHEET 10 (continued)

POLYURETHANE SEALANT (one part)

APPLICATION CHARACTERISTICS

Ease of application: Difficult

Primer requirements: Primer required for some surfaces

Temperature requirements: Above 4.4°C

Approximate drying time to touch: Tacky until weathered
to cure: 14-30 days

Shrinkage: Nil

Handling precautions: Precautions are necessary such as ventilation to remove potentially toxic vapours and gloves to prevent skin contact.

ADVANTAGES

- Elastic; can flex without permanent deformation
- Superior recovery from deformation
- Good for large moving joints
- Good for concrete joints and traffic surfaces
- Especially good adhesion to masonry

LIMITATIONS

- Can only be applied at temperatures above 4.4°C
- Primer needed to enhance adhesion to a number of sufaces
- Careful surface preparation required
- Gloves required during application
- May not adhere to some plastics
- Ventilation needed during application and curing
- Should not be used in joints where the sealant will be in direct contact with asphaltic or tar compound

DATA SHEET 10 (continued)

POLYURETHANE SEALANT (one part)

USES

Polyurethane sealants are formulated to use as either a self levelling sealant for horizontal joints such as floors, or as a non-sag sealant for vertical joints on walls. This sealant bonds to glass, anodized aluminum, concrete, wood, and masonry and is suitable for continued exposure to water. The sealant is for exterior and interior use; however, handling precautions are required on application.

DATA SHEET 11

URETHANE FOAM SEALANT (one or two part)

GENERAL

Technical description: Isocyanurate/polyol polymer foam sealant

Types available: Foam dispensing system with spray nozzels (or individual aerosol spray cans)

Typical colours: Normally white-tan. Will yellow on exposure

Typical price: High cost

Odour while curing:

Toxicity: Potentially toxic

SERVICE CHARACTERISTICS

Typical service life (interior use): 10-20 years

In service temperature range: -40°C to 121°C

Resistance to water immersion: Fair
to abrasion: Poor
to fire: Poor to fair

Adhesion to dry surfaces: Good
to wet surfaces: Poor to fair

Maximum joint size: Suitable for large gaps. Refer to Manufacturer's instructions.

Maximum joint movement: ±1%

DATA SHEET 11 (continued)

URETHANE FOAM SEALANT (one or two part)

APPLICATION CHARACTERISTICS

Ease of application: Easy to difficult

Primer requirements: Use of primer may improve adhesion on some surfaces

Temperature requirements: Above 2°C

Approximate drying time to touch: 1 hour or less
to cure: 1 day or less

Shrinkage: Nil. Urethane foams expand on application. Two part foams expand quickly and greatly; one part foams expand slowly and moderately.

Handling precautions: Precautions are necessary, such as ventilation to remove potentially toxic vapours and gloves to prevent skin contact.

ADVANTAGES

- Very good for filling larger joints and cavities where conventional sealant materials would not be suitable
- Cured urethane foam has insulating properties
- Variable densities and curing time dependant on mixing

LIMITATIONS

- Not good for moving joints
- Preheating necessary if chemical components are below 21°C before application
- Will not adhere to polyethylene, teflon, or silicone plastics
- Clean up is difficult if foam has cured; requires removal by scraping or cutting away excess material
- Sealant has high flame-spread rate. It must be covered and protected

DATA SHEET 11 (continued)

URETHANE FOAM SEALANT (one or two part)

USES

Urethane foams are generally used for sealing in inaccessible locations or in wide joints having minimum movements (header/joist intersections, cavity walls, and around window/door frames. Other potential applications are to seal around plumbing and vent openings or joints in wall panel materials.

DATA SHEET 12

ACOUSTICAL SEALANT

GENERAL

Technical description: Butyl polybutene non-hardening, non-skinning sealant

Types available: Gun grade

Typical colours: Brown, black, grey

Typical price: Low cost

Odour while curing: Aromatic

Toxicity: Non-toxic

SERVICE CHARACTERISTICS

Typical service life: Over 20 years, if used as an acoustical sealant on recommended surfaces, as suggested by manufacturer.

In service temperature range: -40°C to 82°C

Resistance **to water immersion:** Fair
to abrasion: Poor
to fire: Fair

Adhesion to dry surfaces: Excellent for metal, concrete, and gypsum
to wet surfaces: Poor

Maximum joint size: 16 mm

Maximum joint movement: ± 10%

DATA SHEET 12 (continued)

ACOUSTICAL SEALANT

APPLICATION CHARACTERISTICS

Ease of application: Easy

Primer requirements: Generally no primer required

Temperature requirements: Above -15°C

Approximate drying time to touch: 52 hours
to cure: -

Shrinkage: variable

Handling precautions: Precautions are necessary; eg. ventilation during curing to remove flammable vapours.

ADVANTAGES

- Exceptional adhesion and flexibility on recommended surface materials
- Non-hardening and non-skinning
- Maintains a positive air-tight seal
- Absorbs normal joint movement without adhesive failure
- Excellent workability; guns at low temperatures
- Non-staining when used as recommended

LIMITATIONS

- Will collect dust and dirt when used on exposed surfaces
- Cannot be painted if left exposed
- May be sticky or stringy during application
- Bonding to porous wood surfaces may result in loss of solvents and some drying of sealant
- Due to non-hardening characteristics, clean up after application more difficult.

DATA SHEET 12 (continued)

ACOUSTICAL SEALANT

USES

Acoustical sealants were originally manufactured for use as an effective seal to reduce sound transmission through partition walls. Because of their non-hardening, non-skinning characteristics, they have found wide use in the sealing or bonding of polyethylene sheet materials such as air-vapour barriers. Acoustical sealants have also found use in providing seals in unexposed joints; however it is recommended that this sealant only be used if it meets all requirements of the joint to be sealed (ie. joint size, movement, and materials adhesion).

DATA SHEET 13

SILICONE RTV FOAM SEALANT

GENERAL

Technical description: Two component room temperature vulcanized silicone sealant

Types available: A and B two component containers or special applicator caulking gun

Typical colours: Dark grey-black

Typical price: High cost

Odour while curing: ——————

Toxicity: Non-toxic

SERVICE CHARACTERISTICS

Typical service life (exterior use): Unknown

In-service temperature range: -55°C to 200°C

Resistance **to water immersion:** Good
to abrasion: ————
to fire: See below

Adhesion to surfaces: Good adhesion to most surfaces

Maximum joint size and **Maximum joint movement:**

Upon curing, the foam will adhere to many common materials and can furthermore provide excellent seals due to the creation of a tight fit even without actual adhesion to the surfaces.

DATA SHEET 13 (continued)

SILICONE RTV FOAM SEALANT

APPLICATION CHARACTERISTICS

Ease of application: Difficult

Primer requirements: Adhesion to most materials can be improved by using special primer

Temperature requirements: 13°C to 27°C

Approximate drying time to cure: Dependent on the temperature of the A and B components. Typical cure time is 1 1/2 minutes.

Shrinkage: Nil

Handling precautions: Toxicological studies indicate that no significant special handling precautions are necessary. Due to the evolution of hydrogen gas during curing, adequate ventilation is recommended. Keep away from sparks or flame during mixing.

ADVANTAGES

- Easily removed and repaired; retrofit foam adheres integrally to original foam
- Does not melt or soften at high temperatures
- Foams and cures to give a tight compression fit
- No volatile solvents
- Has improved fire-resistant properties

LIMITATIONS

- Application is difficult for residential use
- High cost, may be substituted by the use of conventional silicone sealants if service temperatures are low
- Requires a firm backing material to allow the formation of the seal during cure
- Will not adhere to polyethylene, polypropylene, teflon, or related materials
- Temperatures lower than 23°C (72°F) will result in significantly longer cure rates

SILICONE RTV FOAM SEALANT

USES

Silicone RTV Foam Sealant was specifically formulated for improved fire resistance properties. In commercial applications, it is suitable for preparing foamed-in-place fire stops. It can provide penetration seals for gaps and holes in walls, ceilings and floors through which conduits, cables, ductwork, and piping must pass. It is recommended that specific application information be directed to the product manufacturers.

It should be specially noted that not all silicone foams have improved fire resistance properties. Refer to the manufacturer's information or Underwriter's Laboratories for product-specific information.

Appendix 2.
Data Sheets on Weatherstripping Materials

WEATHERSTRIPPING MATERIALS

INTRODUCTION

This Appendix contains five data sheets. These outline the general advantages and limitations of the various "active" materials used in weatherstripping products. (The "active" materials are those that actually make the seal with the door or window. Frequently, they are mounted in a backing of wood, aluminum, etc.). Note that the data sheets do not consider the lowest quality materials (felt, for instance) since these should not be used in quality air sealing work.

The data sheets cover the following materials:

Data Sheet 1:	Rubber (EPDM or neoprene)
Data Sheet 2:	Plastics (PVC, TPR, or polypropylene)
Data Sheet 3:	Metal (steel, bronze, or brass)
Data Sheet 4:	Pile
Data Sheet 5:	Magnetic strips

Selection of the proper weatherstripping product for a given job depends upon factors other than just the properties of the "active" material. For a fuller discussion of weatherstrip selection, refer to Chapter 7.

DATA SHEET 1

RUBBER (EPDM or NEOPRENE)

TECHNICAL DESCRIPTION

A combination of synthetic elastomers and various additives which are cross-linked through chemical reaction. In this Manual, all references to "rubber" weatherstripping materials mean a good quality rubber compound with EPDM or Neoprene as the primary elastomer.

ADVANTAGES

- Due to the cross-linking mentioned above, rubber has good memory and compression set resistance.
- The inherent properties of EPDM and, to a lesser degree, neoprene, make for superior reistance to the effects of heat, cold, ozone, oxidation, and ultraviolet light. Life expectancy is rated at 25 years plus for both elastomers.
- Rubber does not shrink or crack. It has excellent impact resistance and good abrasion resistance.
- Rubber remains flexible at low temperatures and can be installed in sub-zero temperatures without any special handling.
- Rubber is available in various colours and at a moderate cost.

LIMITATIONS

- Rubber cannot be made into rigid parts that need structural strength
- Rubber cannot be extruded in the very thin strips that are required for some weatherstripping applications.

DATA SHEET 2

PLASTICS (PVC, TPR, or POLYPROPYLENE)

TECHNICAL DESCRIPTION

PVC - polymerized vinyl chloride monomer to which is added various additives to soften the PVC, to make it flexible, and/or to protect it from environmental conditions.

TPR - a mixture of thermoplastic and rubber which attempts to add some rubber properties to the thermoplastic.

Polypropylene - polymerized propylene.

ADVANTAGES

- Plastics can be produced in rigid parts such as channels and "V" seals.
- Plastics can be produced in very thin strips.
- Plastics can be produced in various colours at low cost
- Polyproplylene has a reasonable life expectancy, is not adversely affected by normal cold temperatures, and has a reasonable memory in applications such as plastic "V" seals.

LIMITATIONS

- Over time, PVC may deteriorate in various ways. For instance, it may shrink, lose its flexibility, become difficult to compress, and become susceptible to the effects of ultraviolet light, ozone, and oxidation. The result is a short life expectancy, much below that of rubber.
- PVC requires special handling in cold weather. Care must be taken when installing in sub-zero temperatures.
- At very high temperatures, which can sometimes occur between windows and between doors, plastic weatherstripping may set in a compressed form.

DATA SHEET 3

METAL (STEEL, BRONZE, or BRASS)

TECHNICAL DESCRIPTION

Alloys of various ferrous and non-ferrous metals.

ADVANTAGES

- Metal strips have considerable resistance to environmental conditions and so can have a long life.
- Metal strips do not shrink.
- Metal strips are available in colours at a low cost.

LIMITATIONS

- Metal strips have little compression set resistance when bent. They are easily deformed and made ineffective.
- Metal strips cannot be used as a compression seal.
- Cold will make metal strips susceptible to cracking on flexing.

DATA SHEET 4

PILE

TECHNICAL DESCRIPTION

Short fibres (usually polyester or polypropylene) held together to create a line of material.

ADVANTAGES

- Pile produces little friction when used as weatherstripping in sliding windows and doors.
- Pile provides a good air seal when dry and new.
- Pile is available at a low cost.

LIMITATIONS

- Pile has a very high rate of wear and a very short life expectancy.
- Pile creates a poor air seal when wet and old.

DATA SHEET 5

MAGNETIC STRIPS

TECHNICAL DESCRIPTION

A magnetic strip encased in a flexible PVC sheet which is attached to the door or window frame. The magnetic strip is attracted to steel doors or to metal strips mounted on other doors/windows.

ADVANTAGES

. Magnetic strip systems provide a good seal in moderate climatic conditions.

LIMITATIONS

. Magnetic strips encased in PVC have the limitations of PVC. For instance, due to the hardening of PVC in cold weather, the magnetic force may be insufficient to produce a seal along the full length of the weatherstrip in cold weather.

. Magnetic strip systems require that steel strips be applied to wood doors in order for the system to work.

. Magnetic strip systems have a high cost.

Appendix 3.
Feedback Form

FEEDBACK FORM

The Buildings Energy Technology Transfer Program would appreciate your comments on this Manual:

1. Degree of technical content

Is the manual

☐ too technical and detailed?

☐ too simple?

☐ about right?

Comments: ______________________

____

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2. Ease of reading

Is the manual

☐ easy to read?

☐ hard to read?

Comments: ______________________

____

____

3. Additional topics

Are there additional topics that should be covered by the Manual?

☐ yes

☐ no

Comments: ______________________

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4. Section I - Principles

Comments: ____________________

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5. Section II - Assessment

Comments: ____________________

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6. Section III - Practices

Comments: ____________________

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7. Other Comments: ____________________

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8. Would you like to receive updates of this publication if any are issued?

☐ yes ☐ no

If yes, please enter your name and address:

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Please mail your replies to questions 1-8 to:

Buildings Energy Technology Transfer Program
Energy, Mines and Resources
460 O'Connor Street
Ottawa, Ontario
K1S 5H3

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The Canadian General Standards Board (CGSB) Working Group on Air Sealing is currently developing a provisional Standard on Air Sealing of Homes for Energy Conservation. To assist in its work, the Working Group would appreciate receiving your comments on this draft Manual. Your input will be particularly useful if you:

. Reference precise sections of this draft, rather than make general comments;

. Provide alternative text, rather than simply disagreeing with what is currently written;

. Provide technical substantiation for major points by referencing a published technical report or providing a detailed description of field experience.

Among the topics of interest to the Working Group are problems and solutions peculiar to particular regions, due to regional climates, local building techniques, etc. Health and safety issues - including the avoidance of fire hazards - are also a key concern of the Working Group.

To input to the CGSB Working Group, write:

Canadian General Standards Board
Ottawa, Ontario
K1A 1G6

Attention: Air Sealing

POOR

QUALITY

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